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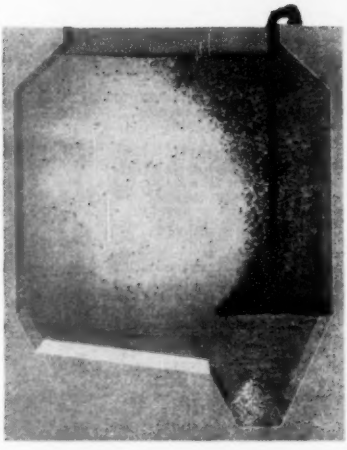

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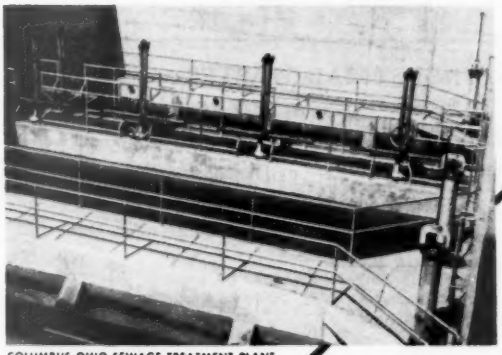

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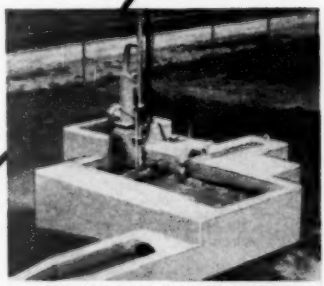

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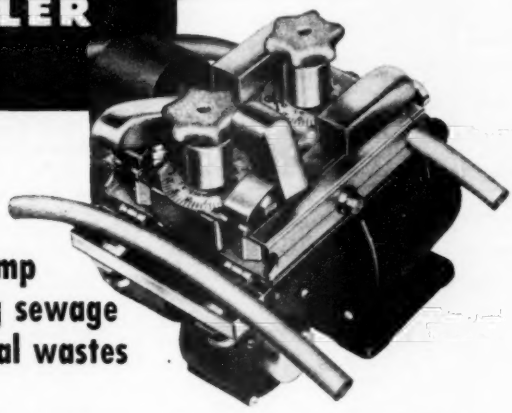

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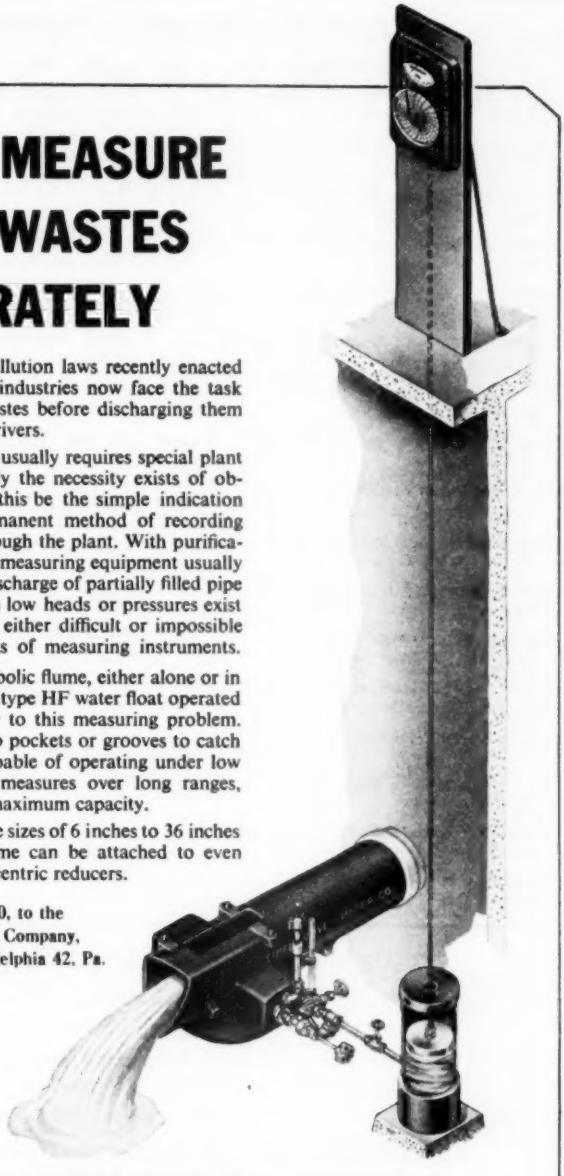

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Association	*Place*	*Time*
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Arizona Sewage and Water Works Assn.	San Marcos Hotel, Chandler, Ariz.	Apr. 16–18, 1953
Kansas Sewage and Industrial Wastes Association	Hotel Broadview, Wichita, Kans.	Apr. 22–24, 1953
California Sewage and Industrial Wastes Association	Mar Monte Hotel, Santa Barbara, Calif.	Apr. 22–25, 1953
Maryland-Delaware Water and Sewerage Association	Commander Hotel, Ocean City, Md.	May 20–21, 1953
Virginia Industrial Wastes and Sewage Works Association	Hotel Jefferson, Richmond, Va.	May 21–22, 1953
Central States Sewage and Industrial Wastes Assn.	Hotel Pere Marquette, Peoria, Ill.	June 3–5, 1953
New England Sewage and Industrial Wastes Association	Laconia Tavern, Laconia, N. H.	June 4–5, 1953
Alabama Water and Sewage Association	Univ. of Alabama, University, Ala.	June 8–12, 1953
New York Sewage and Industrial Wastes Association	Hotel Sheraton, Rochester, N. Y.	June 8–9, 1953
Ohio Sewage and Industrial Wastes Treatment Conference	Mayflower Hotel, Akron, Ohio	June 17–19, 1953
Pennsylvania Sewage and Industrial Wastes Assn.	Pa. State College, State College, Pa.	Aug. 26–28, 1953
West Virginia Sewage and Industrial Wastes Association	Hotel Morgan, Morgantown, W. Va.	Sept. 2–3, 1953
Iowa Sewage Works Assn.	Iowa State College, Ames, Iowa	Sept. 2–4, 1953
Rocky Mountain Sewage Works Association	Hotel La Fonda, Santa Fe, N. M.	Sept. 21, 1953
Kentucky-Tennessee Industrial Wastes and Sewage Works Assn.	Owensboro Hotel, Owensboro, Ky.	Sept. 21–23, 1953
Missouri Water and Sewerage Conference	Elms Hotel, Excelsior Springs, Mo.	Sept. 27–29, 1953

TWENTY-SIXTH ANNUAL MEETING

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in conjunction with
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Municipal (Bayfront Park) Auditorium, Miami, Florida
October 13–16, 1953

Address hotel reservation requests to: FSIWA Convention Housing Bureau, 320 N.E. Fifth Street, Miami, Florida

North Carolina Sewage and Industrial Waste Association	Sheraton Hotel, High Point, N. C.	Nov. 9–11, 1953
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Oklahoma Water, Sewage and Industrial Waste Conference	Okla. A & M College, Stillwater, Okla.	Nov. 16–20, 1953

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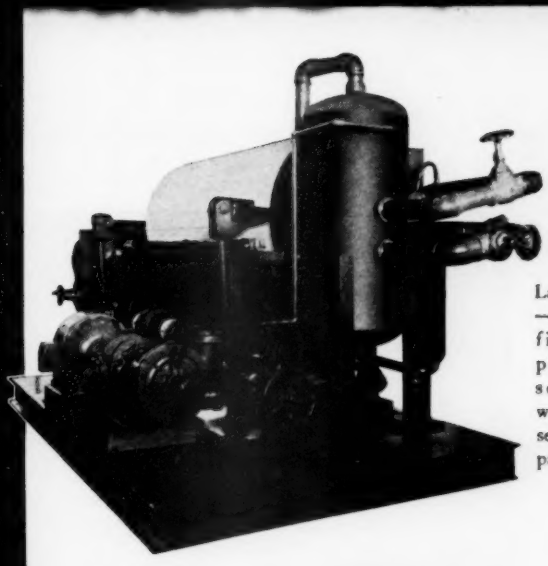

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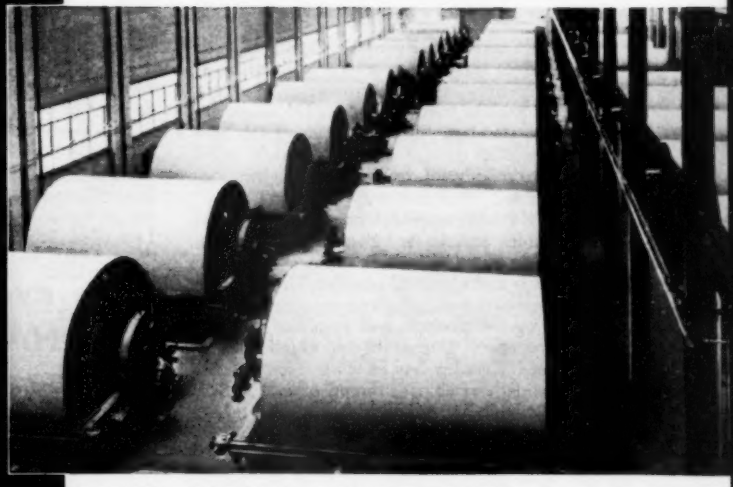

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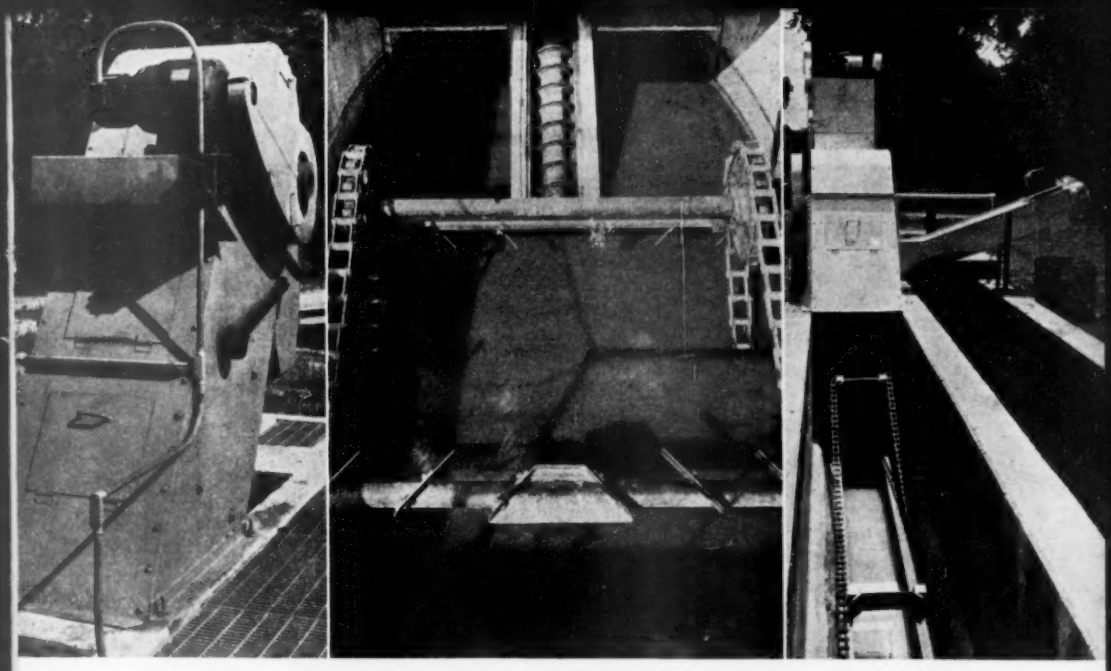


TRITOR SCREENS—At small sewage treatment plants—where grit creates a problem during storm flows, this one machine accomplishes the effective, low-cost removal of both screenings and grit.

STRAIGHTLINE GRIT CHAMBERS—For the removal of a clean, washed grit with a low putrescible content. The complete collection and thorough cleaning operation makes further handling unnecessary.

STRAIGHTLINE GRIT COLLECTORS—On this bucket type collector, water sprays wash the grit from the buckets into a separate washing and dewatering screw. Photo also shows Link-Belt Bar Screen.

How to get flexible, low-cost grit removal

LINK-BELT can give you equipment best suited to your requirements

DON'T let grit plug your pipe lines . . . wear out your pumps . . . take up valuable space in your digesters. Link-Belt builds effective grit removal equipment that assures both low costs and flexibility.

For example, with the Tritor Screen, a grinder may be used to shred the screenings when no grit is received. During storms, the grinder may be by-passed and grit and screenings disposed of by fill, burial or incineration. Similarly, the Straightline grit collector is designed either with a pitched flight collector and dewatering and washing screw discharging direct from the grit chamber—or with a bucket type collector for deep chambers.

In addition to grit handling and washing equipment, Link-Belt manufactures a complete line of equipment for water, sewage and industrial waste treatment plants. A call to the Link-Belt office near you will put you in touch with an experienced sanitary engineer. He'll work with your engineers, chemists and consultants—help you get the best in modern treatment equipment.

LINK-BELT COMPANY: Plants: Chicago, Indianapolis, Philadelphia, Colmar, Pa., Atlanta, Houston, Minneapolis, San Francisco, Los Angeles, Seattle, Toronto, Springs (South Africa), Sydney (Australia). Sales Offices in Principal Cities.

13.134

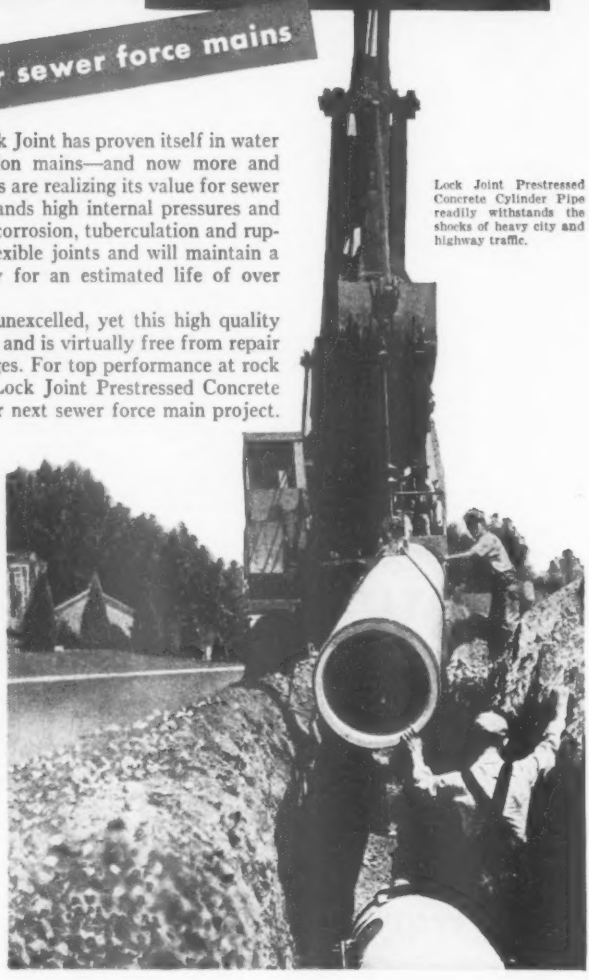
LINK-BELT

SANITARY ENGINEERING EQUIPMENT

LOCK JOINT the ideal pressure pipe for sewer force mains

Through the years Lock Joint has proven itself in water supply and transmission mains—and now more and more sanitary engineers are realizing its value for sewer force mains. It withstands high internal pressures and external loads, resists corrosion, tuberculation and rupture, has watertight flexible joints and will maintain a high carrying capacity for an estimated life of over 100 years.

Its performance is unexcelled, yet this high quality pipe is low in first cost and is virtually free from repair and maintenance charges. For top performance at rock bottom cost, specify Lock Joint Prestressed Concrete Cylinder Pipe for your next sewer force main project.



Lock Joint Prestressed Concrete Cylinder Pipe readily withstands the shocks of heavy city and highway traffic.

Its ability to withstand heavy backloads frequently makes it possible to lay Lock Joint Prestressed Concrete Cylinder Pipe in deep cuts without special bedding. The speed with which it may be laid and the fact that it can be immediately backfilled usually makes it unnecessary to sheet the trench.

SCOPE OF SERVICES—*Lock Joint Pipe Company specializes in the manufacture and installation of Reinforced Concrete Pressure Pipe for Water Supply Distribution Mains in a wide range of diameters as well as Concrete Pipes for Sanitary Sewers, Storm Drains, Culverts and Subaqueous Lines.*

LOCK JOINT PIPE COMPANY

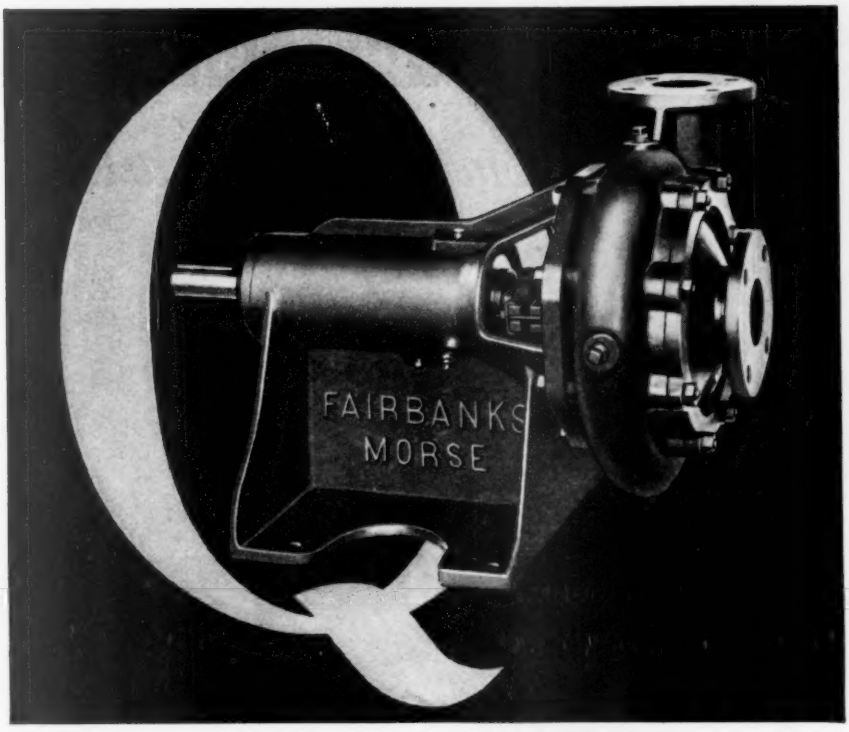
Est. 1905

P. O. Box 269, East Orange, N. J.

PRESSURE PIPE PLANTS:
Wharton, N. J., Turner, Kan., Detroit, Mich.

BRANCH OFFICES: Casper, Wyo. • Cheyenne, Wyo. • Denver, Col. Kansas City, Mo. • Valley Park, Mo. • Chicago, Ill. • Rock Island, Ill. Wichita, Kan. • Kenilworth, N. J. • Hartford, Conn. • Tucumcari, N. Mex. • Oklahoma City, Okla. • Tulsa, Okla. Beloit, Wis. • Hato Rey, P. R.

LOCK JOINT
Reinforced Concrete
PRESSURE PIPE



it's your "Q"

Quality . . . that costs no more is yours when you choose Fairbanks-Morse Side-Suction Centrifugal Pumps. Extensive engineering laboratories . . . production line methods with precision machining of all parts enable Fairbanks-Morse to offer you a side-suction centrifugal with the design, workmanship and performance normally obtained only in highest quality split-case pumps.

Open type, single suction, high efficiency impeller . . . ball-bearing frame construction for long life and smooth operation . . . one-piece, solid cast frame . . . close-grained smooth cast iron volute . . . are among the many big pump features you'll find in these moderate priced side-suction centrifugals.

For a "cue" to better pump performance, choose the pumps that spell quality with a capital "Q" . . . Fairbanks-Morse Side-Suction Centrifugals. Fairbanks, Morse & Co., 600 S. Michigan, Chicago 5, Ill.

FAIRBANKS-MORSE

a name worth remembering when you want the best

PUMPS • DIESEL LOCOMOTIVES • ELECTRICAL MACHINERY • SCALES • HOME WATER SERVICE EQUIPMENT • RAIL CARS • FARM MACHINERY • MAGNETOS

Pollution abatement

has passed from the `Talking' *to the* `ACTING' *stage*

These two timely bulletins will help you act on your waste problem

Here's useful information on waste treatment . . . including equipment description, specifications, flow diagrams and actual case histories of plating, refinery, metal finishing, phenolic and other wastes. These bulletins are yours for the asking.

ACT NOW . . . send this coupon today!

INFILCO INC.
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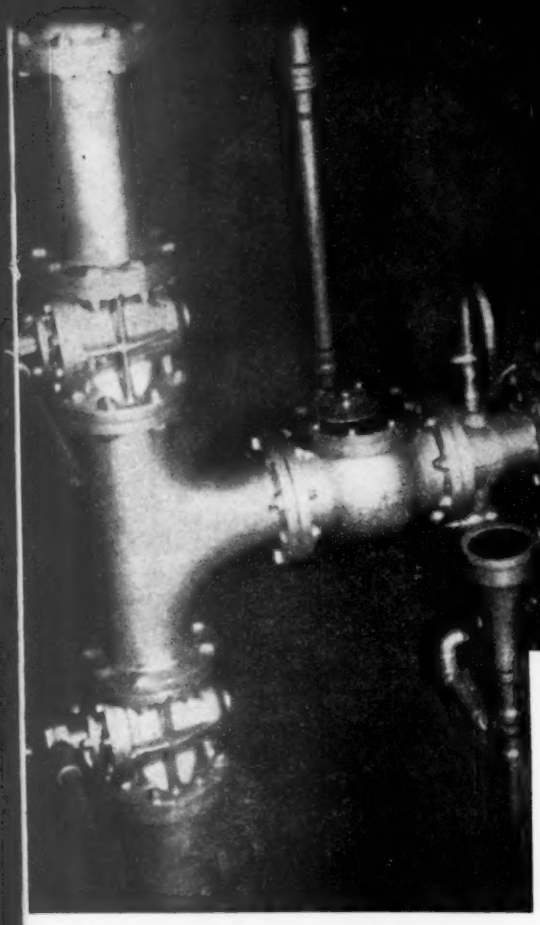
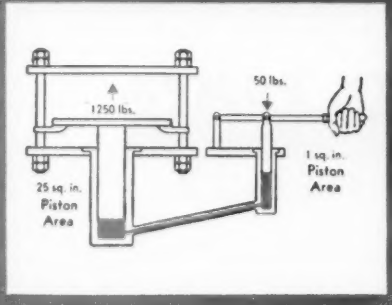


Operator closes Nordstrom valve installed on a pump line in a Midwest sewage treatment plant.

APPLICATION OF PASCAL'S LAW TO NORDSTROM VALVES

Nordstrom valves use the scientific principle known as "Pascal's Law", which states that "pressure applied to a confined fluid is transmitted uniformly to all areas of the confining surface." Thus, lubricant pressure developed by a turn of the lubricant screw exerts a powerful "jacking" action on the plug making it easy to turn, spreads a fresh film of lubricant over the seating surfaces, and surrounds each part with a pressurized seal.



IN SEWAGE VALVE SERVICE YOU NEED NORDSTROM'S INTERNAL *Lubrication*

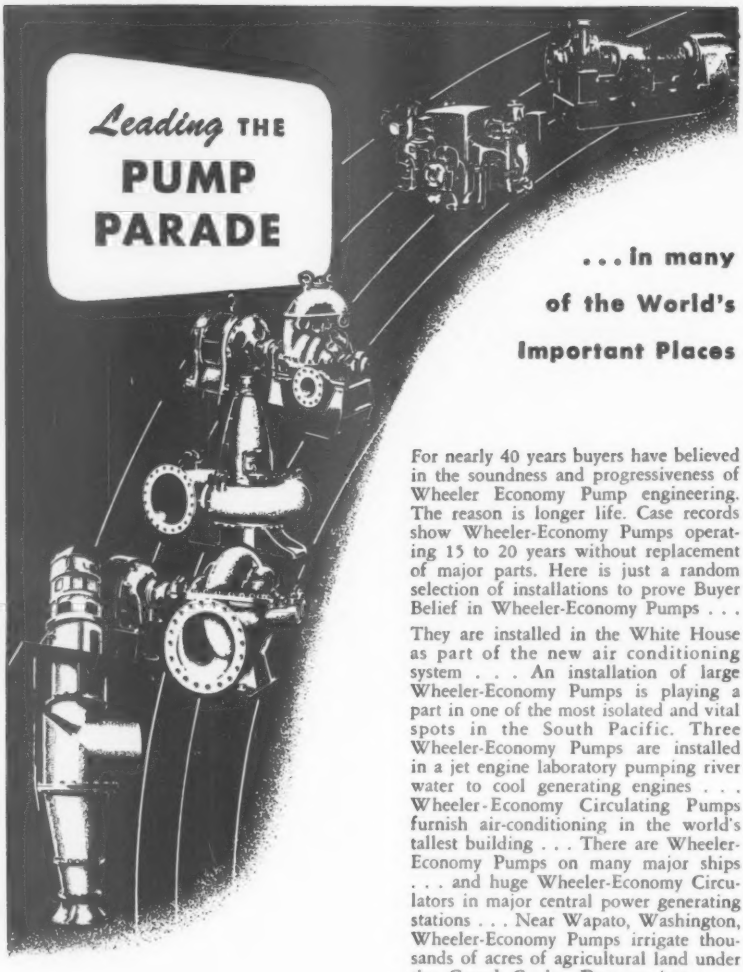
Nordstrom Lubricant-Sealed valves have been installed on sewage treatment lines country-wide with more than a quarter century of trouble-free operation.

There's a reason for Nordstrom's longer valve life and superior performance. All Nordstroms give you the basic advantage of Nordstrom design—an internal lubrication system which provides a positive seal against leakage, protects vital seating surfaces, and keeps the valve ready to operate easily at any time.

When you specify valves for sewage treatment services, call your Nordstrom representative. His advice will save you time, effort and money. Rockwell Manufacturing Company, Pittsburgh 8, Pennsylvania.

ROCKWELL Built Nordstrom Valves
Lubricant-Sealed for Positive Shut-Off

Another ROCKWELL product



. . . In many of the World's Important Places

For nearly 40 years buyers have believed in the soundness and progressiveness of Wheeler Economy Pump engineering. The reason is longer life. Case records show Wheeler-Economy Pumps operating 15 to 20 years without replacement of major parts. Here is just a random selection of installations to prove Buyer Belief in Wheeler-Economy Pumps . . .

They are installed in the White House as part of the new air conditioning system . . . An installation of large Wheeler-Economy Pumps is playing a part in one of the most isolated and vital spots in the South Pacific. Three Wheeler-Economy Pumps are installed in a jet engine laboratory pumping river water to cool generating engines . . . Wheeler-Economy Circulating Pumps furnish air-conditioning in the world's tallest building . . . There are Wheeler-Economy Pumps on many major ships . . . and huge Wheeler-Economy Circulators in major central power generating stations . . . Near Wapato, Washington, Wheeler-Economy Pumps irrigate thousands of acres of agricultural land under the Grand Coulee Dam project . . .

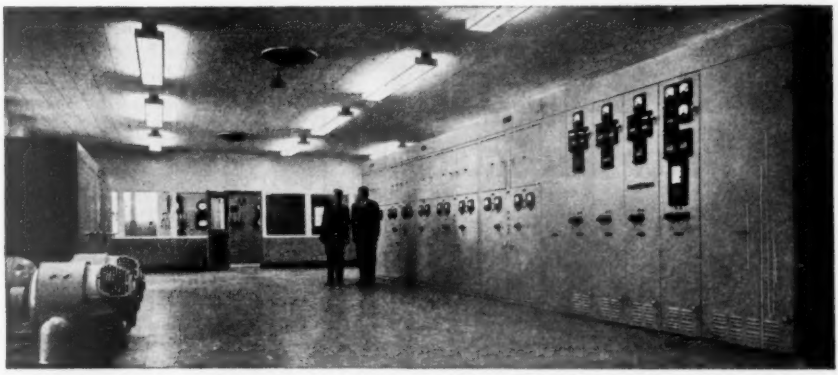
And this is only a small part of the record. There are Wheeler-Economy Pumps for every pumping need from small units for equipment manufacturers to giants of 200,000 GPM.

There's a distributor or district office as near as your phone. Look him up.

E-137-R

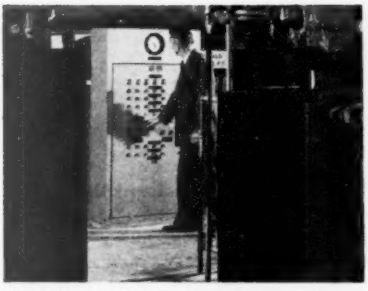
WHEELER-ECONOMY PUMPS

ECONOMY PUMPS, INC. - DIVISION OF C. H. WHEELER MANUFACTURING CO.
19TH AND LEHIGH, PHILADELPHIA 32, PA.



Typical of modern G-E equipment is this switchgear and Limitamp control lineup at a new west coast plant.

3-way aid for your Clean Waters plan



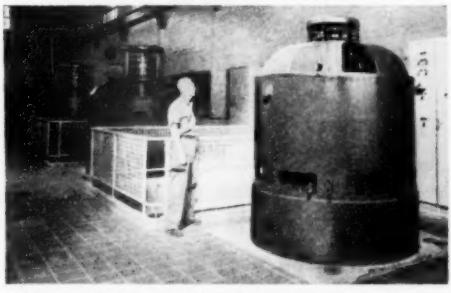
Special control like this chlorinator panel is part of complete G-E equipment for sewage plants.

Available now to all communities faced with the need for new or expanded sewage-treatment facilities is this three-way help from General Electric:

1. **Community-action program,** including the film *Clean Waters* to aid you in increasing public support for necessary new projects.
2. **Engineering assistance** to your consultants or engineers in electrical-system planning.
3. **Co-ordinated electrical equipment** supplied from the complete G-E line of motors, control and power distribution equipment.

To take advantage of this complete service, contact your nearest G-E Apparatus Sales Office early in the planning of your project. General Electric Co., Schenectady 5, N. Y. 666-75

Clean Waters program consists of film, manual *Modern Sewage Treatment,* handout leaflets.



G-E motors for sewage-plant use range from these large lift-pump motors to small motors for process drives.

Engineered Electrical Systems for Sewage Plants

GENERAL ELECTRIC

Fair Weather or Foul . . . No Water Can Enter Head to Freeze, No Sediment Can Reach Operating Thread

MATHEWS
HYDRANTS

Made by R. D. Wood Company

Public Ledger Building, Independence Square
Philadelphia 5, Pa.

Manufacturers of "Sand-Spun" Pipe (centrifugally cast in sand molds) and R. D. Wood Gate Valves

• The stuffing box plate, cast integral with the nozzle section, covers the entire area of the head and, with the packing, prevents water from reaching the operating thread. This means no rust can form and no sediment can be deposited on the thread to wear and destroy it.

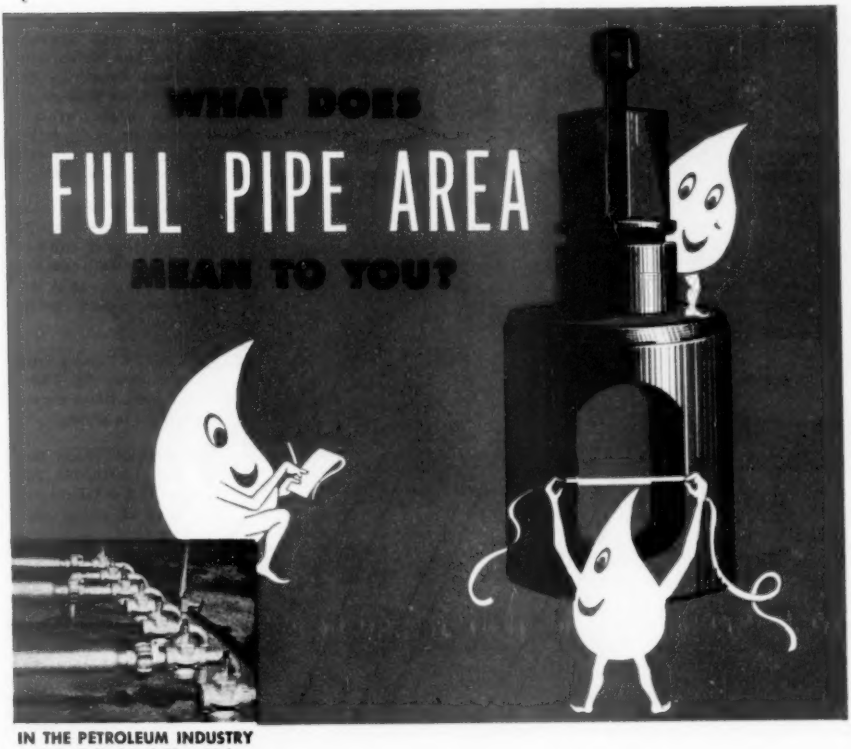
• No matter how cold the weather, the stem thread cannot freeze to the nut, nor can ice form inside it to interfere with closing the hydrant.

• Community fire protection is assured with the installation of Mathews Hydrants—vital links between hose and water main.

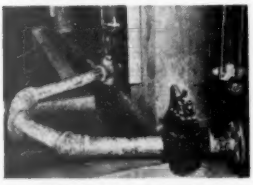
No Other Hydrant Offers So Many Essential Features

Compression type valve prevents flooding • Head turns 360° • Replaceable head • Nozzle sections easily changed • Nozzle sections easily raised or lowered without excavating • Protection case of "Sand-Spun" cast iron for strength, toughness, elasticity • Operating thread only part to be lubricated • All working parts contained in removable barrel • A modern barrel makes an old Mathews good as new • Available with mechanical-joint pipe connections

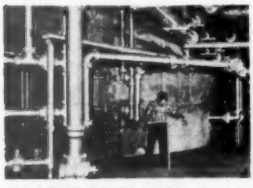
150th anniversary



IN THE PETROLEUM INDUSTRY a.c.f. Cylindrical Plug Valves give full flow, quick quarter-turn shut-off.



ON CHEMICALS viscous heavy ladings or materials in suspension flow freely without turbulence.



IN SEWAGE PLANTS a.c.f. Cylindrical Plug Valves handle raw sewage with ease — plug shears obstructions.

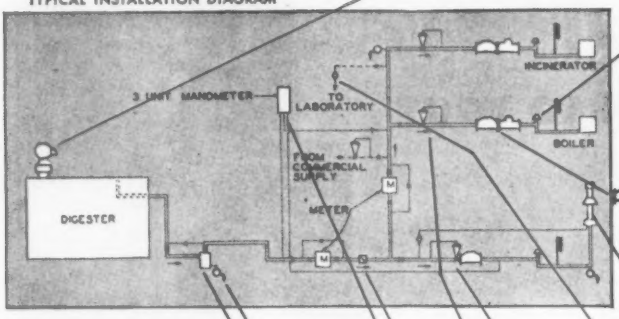
It means, primarily, a smooth, straight-through flow. Look through an a.c.f. CYLINDRICAL Plug Valve, and you'll see why solids in suspension and heavy, viscous ladings pass so easily. There are no restrictions to retard flow! The valve port has an area at least as large as the pipe itself. For the lowest head loss of *any* plug valve in the world, specify a.c.f. CYLINDRICAL, Lubricated Plug Valves. You'll save time and pumping cost!

a.c.f. CYLINDRICAL FULL PIPE AREA PLUG VALVES

Write for Catalogue 4-S1. American Car and Foundry Co., Valve Division, 1501 E. Ferry Ave., Detroit 11, Mich.

Representatives in 50 Principal Cities

TYPICAL INSTALLATION DIAGRAM



"VAREC" Pressure Relief and Vacuum Breaker Valve with Flame Arrester — Fig. 5800C — Relieves excess pressures and vacuum in digesters and protects vessels from outside fires.

"VAREC" Explosion Relief Valve—Fig. 70 — Relieves sudden surges in pressure from explosion or momentary plant fluctuations.

"VAREC" Flame Trap Assembly—Fig. 450—Prevents flame propagation in piping.

"VAREC" Waste Gas Burner—Fig. 236, 237 or 238—Efficiently burns all excess gas.

"VAREC" Flame Check — Fig. 51A or 52A — Prevents flashback from burner pilot or laboratory burners.

"VAREC" Pressure Relief and Flame Trap Assembly—Fig. 440—Permits excess pressure to be wasted through gas burner and prevents flame flashback from burner.

"VAREC" Pressure Reducing Regulator—Fig. 187 or 387—Controls pressure of gas going to utilization equipment.

"VAREC" Check Valve —Fig. 211 or 211A—Controls direction of gas flow.

"VAREC" Manometer —Fig. 215, 215A, 216 or 216A — Indicates system pressures.

"VAREC" Drip Trap—Fig. 245 or 248.

"VAREC" Sediment Trap — Fig. 230, 232 or 233 — Keeps lines drained and free from moisture.

Plan with "Varec" Symbols of Safety

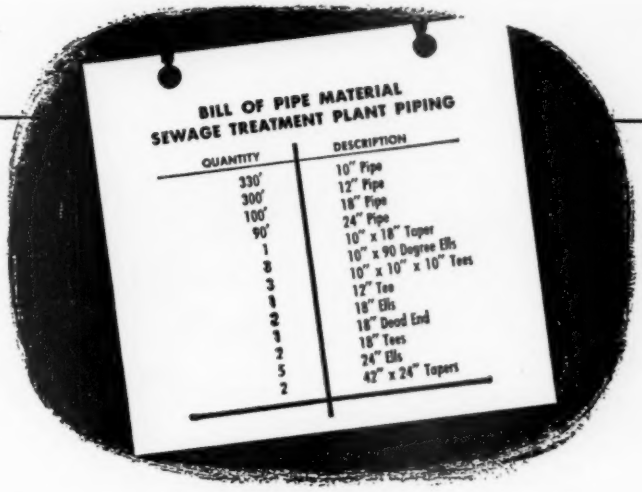
FOR GAS CONTROL THROUGHOUT YOUR SEWAGE TREATMENT PLANT

PROVED and APPROVED "Varec"

THE VAPOR RECOVERY SYSTEMS COMPANY

COMPTON, CALIFORNIA, U. S. A.

S-10 *Available from Authorized Sewage Equipment Agents throughout U. S. and Canada.*



City Saves 60% on Cost of Piping for Treatment Plant

When a northwest city had to enlarge its sewage treatment plant the installed cost of the type of pipe originally considered far exceeded the engineer's estimate. Then they found that by using Armco ASBESTOS-BONDED Pipe they could do an equally good job for 60% less than the original bid.

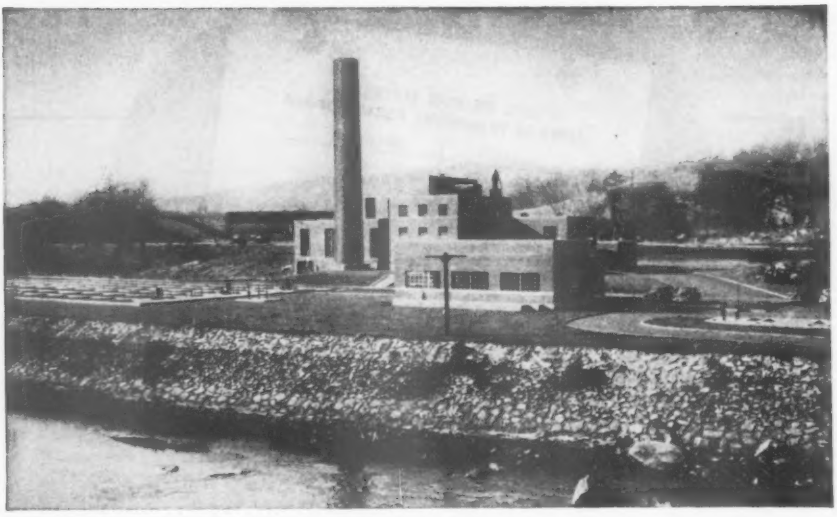
On every item in the bill of materials, Armco ASBESTOS-BONDED Sewer Pipe with a PAVED-INVERT was much lower on an installed cost per foot or per unit. Savings ranged from a minimum of 28% to an astounding 93%!

Armco ASBESTOS-BONDED Pipe provides complete protection against severely corrosive conditions. The PAVED-INVERT guards against erosion. Thus you can use Armco Sewer Pipe with confidence that it will solve your most "difficult" corrosion or erosion problems.

For normal conditions plain galvanized standard pipe will provide long service or you can have the extra protection of bituminous coating. Armco MULTI-PLATE Pipe or Arch extends the advantages of corrugated metal design to larger structures. And either Standard or MULTI-PLATE Pipe-Arch will solve problems of limited headroom. For more details, write us. Armco Drainage & Metal Products, Inc., 1853 Curtis Street, Middletown, Ohio. Subsidiary of Armco Steel Corporation. Export: The Armco International Corporation.

Armco Sewer Structures

ARMCO



New Waterbury Disposal Plant ...flash dries sewage sludge

A large forward step in lowering pollution in Connecticut's Naugatuck River was taken when the city of Waterbury opened its new disposal plant recently. Combining refuse incineration with sludge disposal and high temperature deodorization, the Waterbury plant effectively disposes of wastes for an equivalent population of 100,000.

The C-E Raymond Flash Drying Unit in this new plant is designed to dry over 29 tons of filter cake per day. This is equivalent to an evaporation rate of 2600 pounds per hour. The plant is designed so that the sludge can be dried and marketed as fertilizer, or incinerated to a sterile ash.

The Waterbury plant is typical of C-E Raymond System installations, now in service in virtually all parts of the country, meeting the varying requirements of both large and small communities. They are flexible in layout, highly efficient and thoroughly reliable; they provide for maximum utilization of waste heat.

The services of C-E specialists are available to assist you in finding the best solution to *your* sludge disposal problem. Get in touch with the C-E office nearest you for prompt attention. B-561A

C-E Raymond Flash Dryer Systems installed, under construction or on order since 1945

BALTIMORE, Md.
BETHLEHEM, Penna.
BLOOMSBURG, Penna.
CAMDEN, N. J.
CHICAGO, Ill. (W. Southwest)
FOND DU LAC, Wis.
HOUSTON, Texas
LANSING, Michigan
LOS ANGELES, Calif.
SAN DIEGO, Calif.
SAN FRANCISCO, Calif.
SCHENECTADY, N. Y.
SHEBOYGAN, Wis.
WASHINGTON, D. C.
WYOMISSING VALLEY, Penna.
COLNE VALLEY, England
RECIFE, Brazil

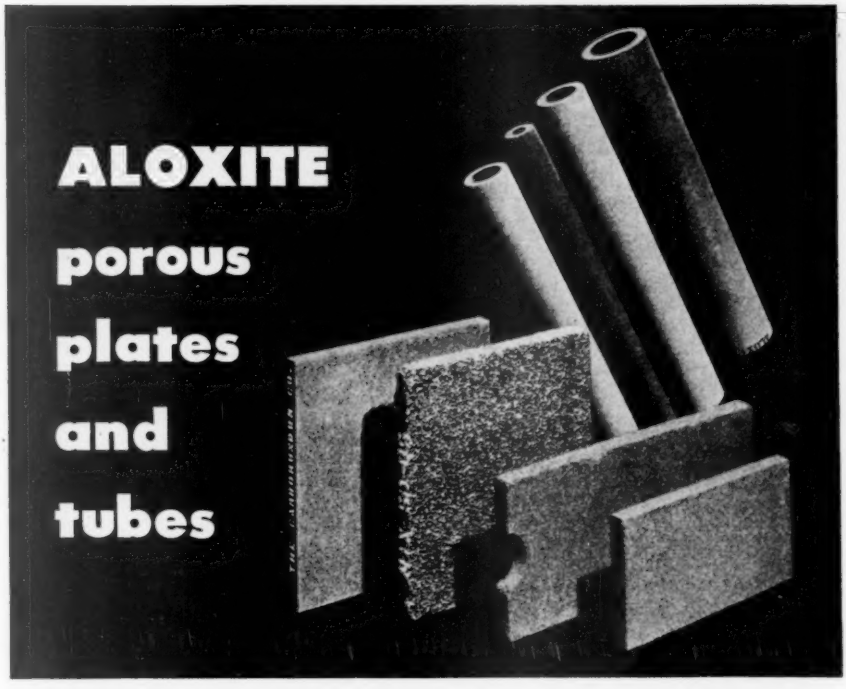
WATERBURY, Conn.

C-E

COMBUSTION ENGINEERING – SUPERHEATER, INC.
FLASH DRYER DIVISION

1315 North Branch Street, Chicago 22, Illinois
Western Office: 560 W. Sixth, Los Angeles 14, Calif. Eastern Office: 200 Madison Ave., N. Y. 16, N. Y.

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT



made from the only TIME-TESTED DIFFUSER MATERIAL

When considering air diffusers, these facts are worth keeping in mind: Of the many aeration methods and materials tried since the discovery of the activated sludge process (in 1915), *only one* has stood the test of time. Only porous ceramic diffusers have been used with continued success. And more installations have been made with ALOXITE aluminum oxide diffusers than all makes combined. Hundreds are still operating – many after over 20 years' service.

The inherent advantages of ALOXITE diffusers are: (1) A highly uniform grain structure. This assures uniform, small-bubble diffusion, and, consequently, optimum absorption. (2) A smooth, low-resistance surface. The glass-like ceramic bond that coats each grain minimizes pressure loss or clogging. (3) Permanent resistance to corrosion. (4) Adaptability to practically all cleaning methods. (5) Great strength and ruggedness.

ALOXITE diffusers are available in plate or tube form, and in a full variety of grades. This permits maximum flexibility of design. It also lets you select the exact grade for optimum diffusion, (consistent with air supply quality, pressure loss characteristics, and overall life). This is particularly important since the introduction of the oxygen absorption test.

Write for free 56-page booklet.

CARBORUNDUM

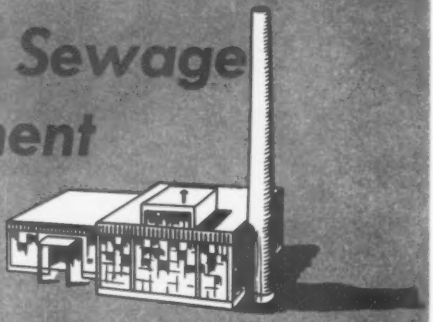
Trade Mark

Dept. N-33, Refractories Div. The Carborundum Co., Perth Amboy, N. J.

"Carborundum" and "Aloxite" are registered trademarks of The Carborundum Co.

How to . .

. . Streamline Sewage Treatment



Dry and/or Burn Sludge with Nichols Multiple Hearth dryer-incinerators. Burn sewage sludge to a sterile ash or dry it for use as a fertilizer.

Use Proved Adaptable Equipment . . . the Nichols Multiple Hearth furnace successfully incinerates sludge in liquid, thickened, raw or digested state. Assures simple, positive, dependable and economical sludge disposal.

Have a Compact, Attractive Plant such as is made possible by use of the Nichols Multiple Hearth Dryer-Incinerator. Unsightly, space-wasting sludge beds, lagoons, dumps and digesters can be eliminated.

The Nichols Multiple Hearth Dryer-Incinerator!

NICHOLS Engineering & Research Corp.

70 PINE ST., NEW YORK 5, N. Y.

1920 N. Meridian St., Indianapolis 2, Ind.
40 S. Los Robles Ave., Pasadena 1, Calif.
1477 Sherbrooke St. W., Montreal 25, Canada

JOSEPH J. RADY, *Engineer*

"A view of a recently completed single-stage Spiraflo Clarifier Plant at Texas City, Texas, taken from on top of the primary Spiraflo Clarifier."

The above plant has one 54-ft. diameter primary Spiraflo which handles an average flow of 3.46 m.g.d. and a maximum flow of 6.05 m.g.d. The 98-ft. diameter filter and the 54-ft. diameter final Spiraflo handle 3.46 m.g.d. with recirculation from the final clarifier back to the filter, during low raw sewage flows. All secondary sludge is returned to the raw sewage wet well, to be returned to the primary tank. Maximum surface rate in the primary is 2640 gal. per sq. ft. per 24 hr.

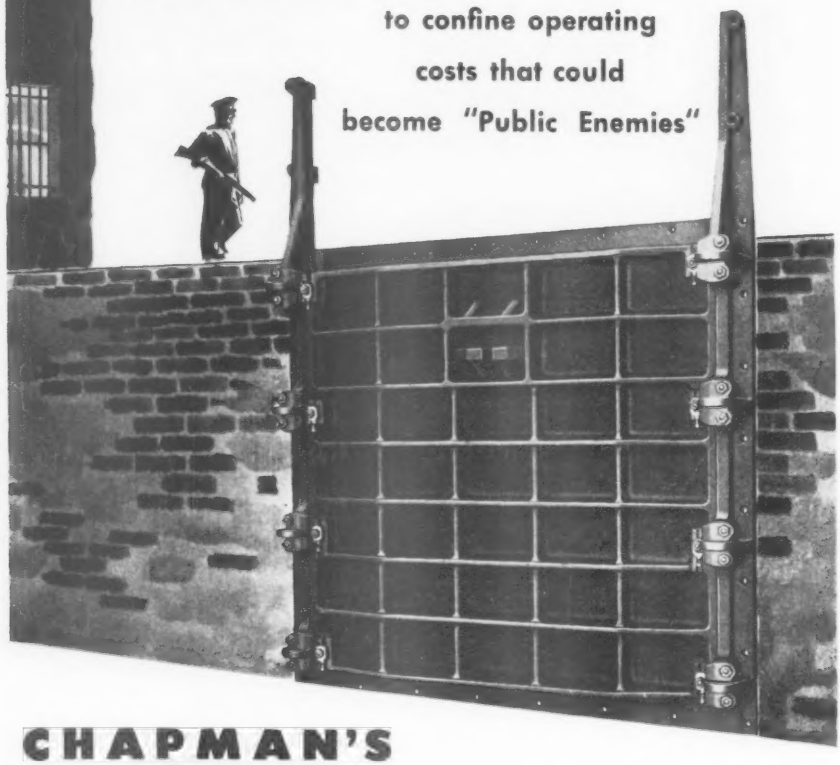
If you would like to improve your sewage plant results, we urge you to investigate the Spiraflo Aero-filter combination in single-stage or two stages. This combination, when treating domestic sewage, is giving over-all B.O.D. removals in single stage of 88 to 92 per cent without the use of parallel recirculation.

LAKESIDE ENGINEERING CORPORATION

222 West Adams Street **Chicago 6, Illinois**

It's the "Guardian Gate..."

to confine operating
costs that could
become "Public Enemies"



CHAPMAN'S
Standard
SLUICE GATE

You shut the gate on excessive costs the moment you specify Chapman Standard Sluice Gates. For installation is fast and foolproof, because the interchangeable stems and couplings need no match-marking.

And then you *lock* the gate on excessive costs . . . for repairs and replacements parts (when and if needed) can be straightway dropped into place *in the field,* without alterations.

What's more, Chapman Standard Sluice Gates can be specified with any type of operating control... manual, hydraulic, or electric. Catalog No. 25 gives complete details and specifications. Write for your copy *now.*

The CHAPMAN Valve Mfg. Co.
INDIAN ORCHARD, MASSACHUSETTS

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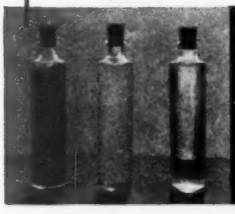
Inset: Raw, First Stage and Final Effluent.



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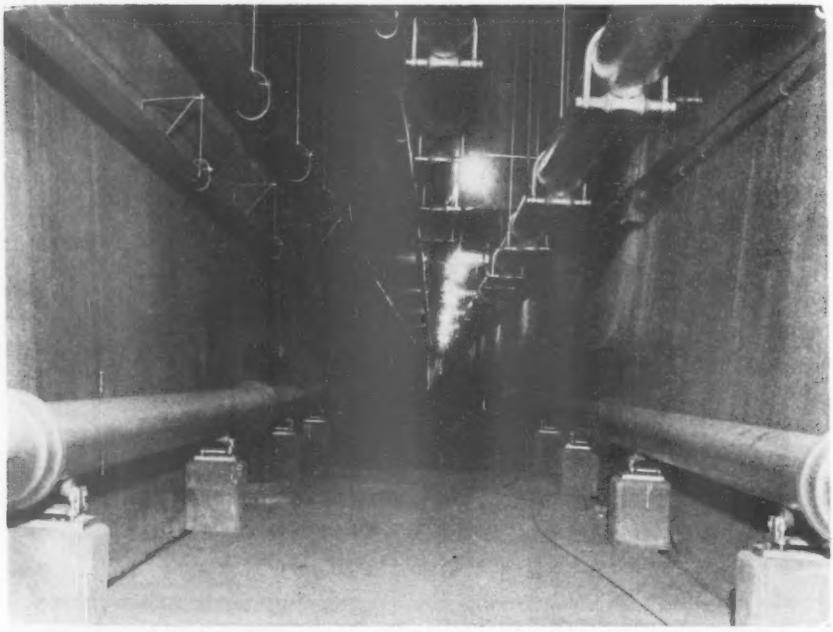

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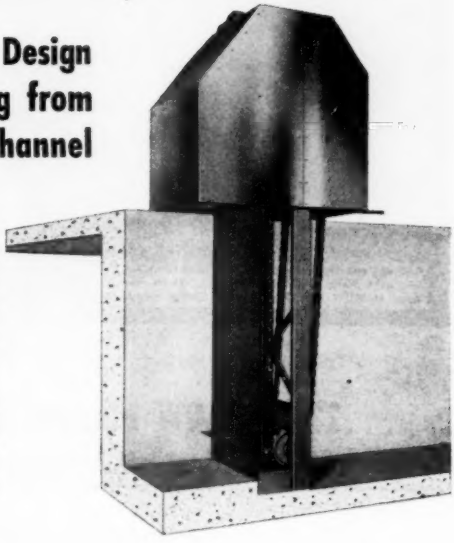
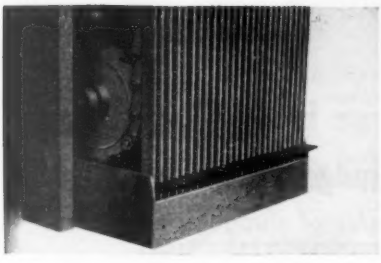
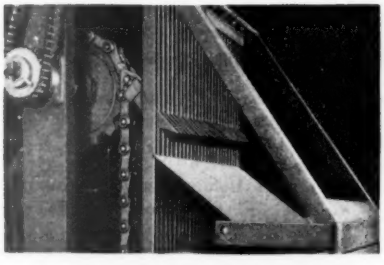




Horizontal position of rake teeth at the beginning of cleaning cycle accomplishes raking from absolute bottom of channel. Gets under and picks up all screenings—does not push them away • Note unobstructed channel approach.



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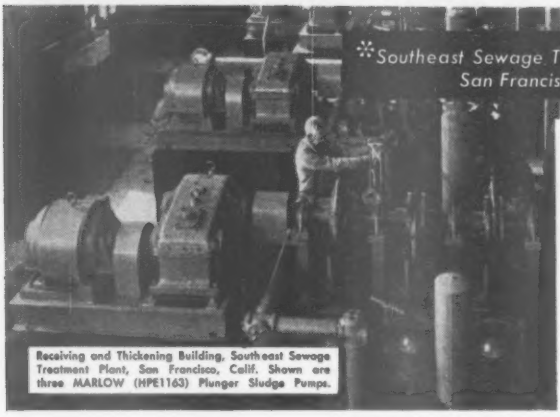
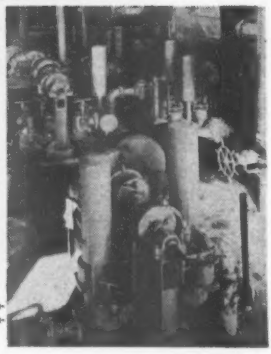


*Southeast Sewage Treatment Plant, San Francisco, California

Receiving and Thickening Building, Southeast Sewage Treatment Plant, San Francisco, Calif. Shown are three MARLOW (HPE1163) Plunger Sludge Pumps.



Filtration and Elutrichion Building, Southeast Sewage Treatment Plant, San Francisco, Calif.

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for *re-circulation, draw-off* and *transfer of sludge*

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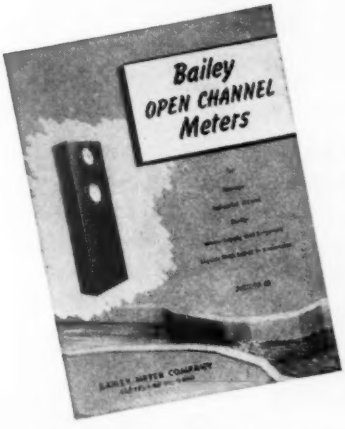

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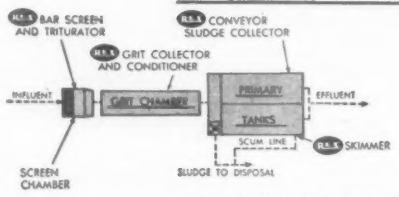

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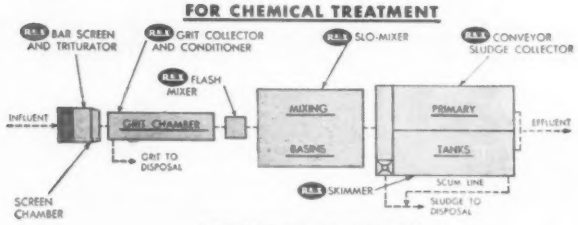

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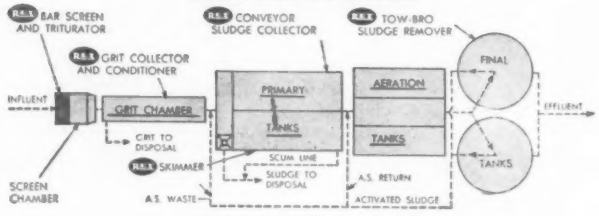

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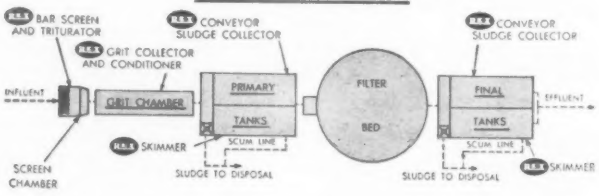

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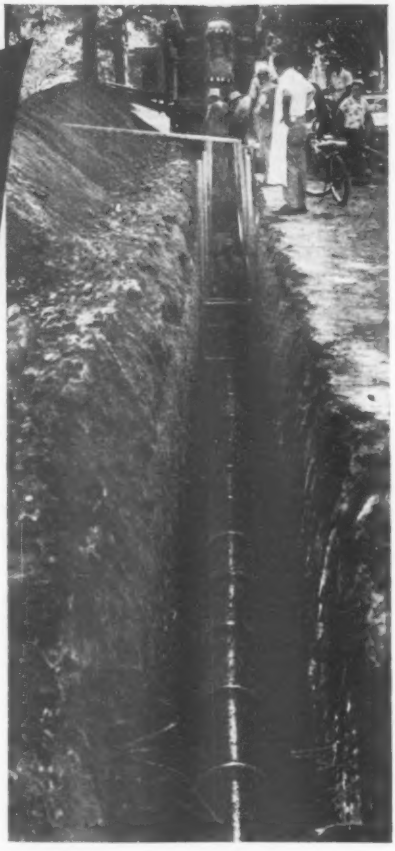

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SEWAGE AND INDUSTRIAL WASTES

Journal of the Federation of Sewage and Industrial Wastes Associations

Volume 25 | March, 1953 | Number 3

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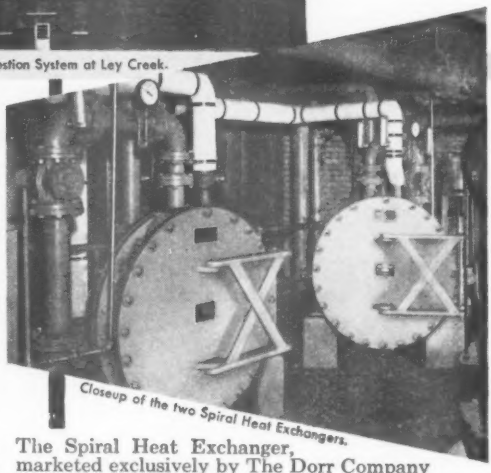
In late 1950, two Spiral Heat Exchangers, each with a rated capacity of 200,000 BTU/hr., were installed at the Ley Creek Sewage Treatment Plant, Syracuse, N. Y.

Reports direct from the Superintendent of the plant conclusively state that the units have operated successfully since initial start-up in January 1951 . . . that there has been no plugging in the Exchangers . . . and that they have done a very good job of heating the digesters, as shown by the data below.

General View of the Dorr Multdigestion System at Ley Creek.

At the Ley Creek Sewage Treatment Plant, Syracuse, N. Y., separate sludge digestion is carried out in a Dorr Multdigestion System with two Primaries and one Secondary. Each Primary is heated by a Spiral Heat Exchanger utilizing cooling water from a gas engine as the heat source. Operating data — for a twelve months period — is summarized below:

Number of units: 2; Rated capacity/unit-200,000 BTU/hr.
Avg. heat transfer—Exchanger #1—223,000 BTU/hr.
Avg. heat transfer—Exchanger #2—261,000 BTU/hr.
Maximum transfer recorded—485,000 BTU/hr.
Minimum transfer recorded—91,000 BTU/hr.



Closeup of the two Spiral Heat Exchangers.

The Spiral Heat Exchanger, marketed exclusively by The Dorr Company in the sanitary engineering field, is a simple, compact, highly efficient method of heating sewage digesters. For further information, including design capacities and sample specifications, write for Bulletin No. 6281, The Dorr Company, Stamford, Connecticut.

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Sewage Works

DETERGENT COMPOUNDS—THEIR COMPOSITION AND BEHAVIOR*

By Lawrence Flett and Lester F. Hoyt

Director and Manager of Detergent Application Research, respectively, New Products Division, Allied Chemical & Dye Corp., New York, N. Y.

The sudden growth of chemical production during the past 30 years has not taken place without the products and by-products becoming factors in waste disposal. Many clever new methods have been put into operation for the processing of these new industrial wastes; and to the extent that the new chemicals enter the home, there has been speculation as to whether they might become a factor in the processing of household wastes.

The most abundant and most useful products of chemical research are the "synthetics," which replace or surpass the gifts of nature. There are, for example, synthetic resins, synthetic rubbers, synthetic dyes, and synthetic drugs. The newest addition to the list is the synthetic detergent, introduced into this country in 1932. Figure 1 shows that the production has increased rather steadily to an annual sales volume of 1,500,000,000 lb. No synthetic organic chemical has enjoyed such a rapid growth in so short a period subsequent to its initial introduction, and forecasters promise a continuing expansion of detergent use.

It so happens that among all the "synthetics," those interested in waste disposal have been most interested in the synthetic detergent. It is used in large quantities, it is all water soluble, and almost every pound of it ultimately finds its way into the sewer.

The synthetic detergent has not replaced soap. As much fatty soap as ever reaches the disposal plant, but in addition to this there is the waste from the use of 1,500,000,000 lb. of detergent. Figure 2 shows the production of synthetic detergents in relation to the consumption of fats and oils by the soap industry. The figures for fats and oils are taken as the best representation of the soap as it is encountered at the disposal plant. Since laundry soaps have soluble alkaline salts as builders, the reported figures for soap production would run 50 per cent higher than the figures as shown. The comparison shows that the upsurge of the synthetic detergent production has not greatly affected the pure soap production.

The marked advance to a higher standard of cleanliness has been made possible by improved soaps and detergents, which make the housework easier, and their increased use in home and industry.

Many Surface-Active Agents

This paper discusses the chemical composition of these new detergents and their physical properties, particularly as these characteristics relate to the operation of wastes disposal.

The synthetic detergents with which the members of the Federation are primarily concerned are the household detergents, which constitute over 80 per cent of the detergent used. Household detergents are made up of a mix-

* Presented at 25th Annual Meeting, Federation of Sewage and Industrial Wastes Assns.; New York, N. Y.; October 6–9, 1952.

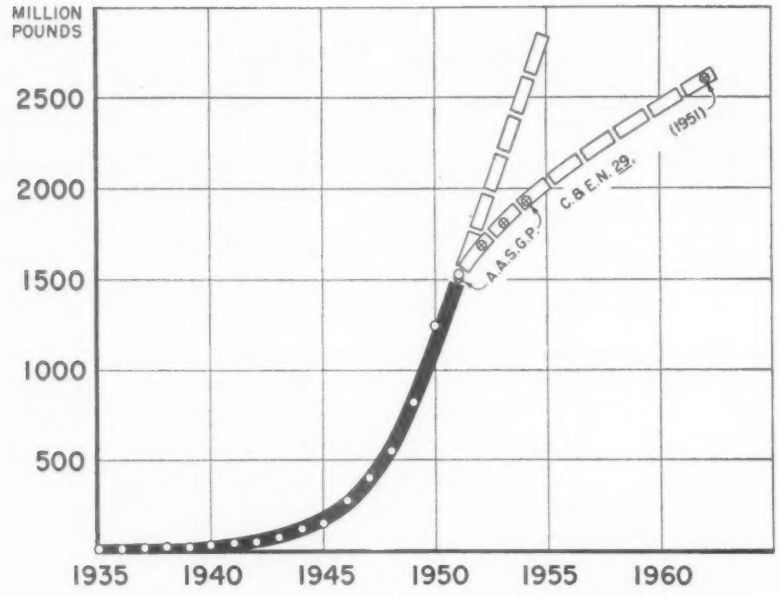

FIGURE 1.—Synthetic detergent production in the United States.

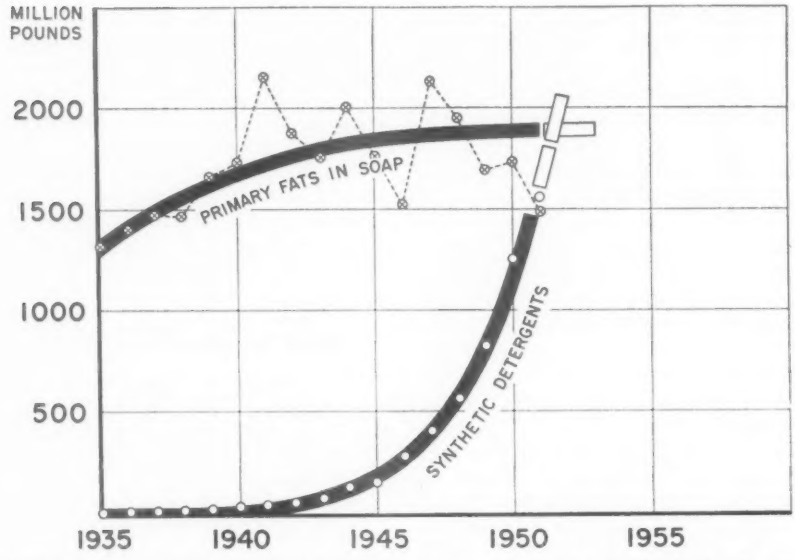

FIGURE 2.—Comparison of production of synthetic detergents and primary fats in soap.

ture of at least three, and sometimes as many as ten individual components, each one of which plays a very specific part in the washing process. The one essential ingredient common to all of the so-called "detergents" is the surface-active agent, often referred to in analyses as the "pure organic detergent." There are available commercially literally thousands of these surface-active agents of every shape and description, representing practically all classes of chemical compounds. The recently published "Encyclopedia of Surface-Active Agents" (1) catalogs more than 2,500 commercial brands.

Few Types Involved in Sewage Treatment

Those concerned with waste disposal problems need not be confounded by the ponderous lists of surface-active agents, because one does not need the fingers of one hand to count those used in a sufficiently large quantity to be of any possible interest as far as their presence in wastes is concerned. These few important products are all organic chemicals characterized by long hydrocarbon chains, and they have either sulfonate or sulfate groups, derived from sulfuric acid, which give the fatty hydrocarbon groups solubility or dispersability in water.

These compounds might be regarded as sodium sulfate, common in all sewage, where a small part of the molecule has been replaced by a large hydrocarbon group. These are the anionic detergents, so-called because the effective hydrocarbon group is in the anion.

There are also cationic detergents and nonionic detergents. The cationic detergents might be regarded as an ammonium chloride, in which at least one hydrogen is replaced by the characteristic fatty hydrocarbon group. They are present in sewage in insignificant amounts and are without effect because they form a completely inactive and insoluble combination with the much more prevalent anionic detergents.

The third class is the nonionic detergents, in which the fatty hydrocarbon group is attached to a sugar-like radical, which provides the water dispersability. These amount to about 3 per cent by weight of the total detergent used. Since the quantity is so small, they are not a source of concern in the ordinary waste disposal system.

The anionic detergents—that is, the organic sulfates and sulfonates—are the only detergents used in sufficient quantities to be of interest to wastes treatment personnel. The ordinary household package of anionic detergent contains a mixture with about 30 to 35 per cent of pure organic detergent. On this basis, it is evident that there would be 400,000,000 to 500,000,000 lb. of pure organic detergent going into the sewers. This provides about 1 to 15 p.p.m. in the sewage reaching the disposal plant, depending on the locality, the day, the time of day, and the flow of water. Three to 15 p.p.m. have actually been found in raw sewage by analysis using a modification of the method of Barr, Oliver, and Stubbings (2).

The other principal constituents in the packaged household detergents include such things as sodium tripolyphosphate, tetrasodium pyrophosphate, sodium sulfate, common salt, other alkaline builders, small amounts of organic builders, and fluorescent dyes. Sodium tripolyphosphate and tetrasodium pyrophosphate have undergone a tremendous development during the past 10 years, some 600,000,000 lb. of the former and 175,000,000 lb. of the latter being manufactured in 1951. These products are added to soap or to detergents and practically all of both products ultimately find their way into the sewer. Salt and sodium sulfate are common to all sewage. The organic builders and fluorescent dyes are present in very small amounts at

present, probably without any effect on waste disposal.

Comparison with Soap

Those concerned with waste disposal will be interested in the behavior of the detergent in comparison with soap and in the properties of the detergents, which determine what form they are in when they reach the disposal plant. Soap is an anionic active agent, but it is such a weak salt that in dilute solution and in acid solution it breaks down to give the fatty acid. It is also precipitated by lime salts, which are inevitably present in water. Because of these factors, soap reaches the sewage disposal plant in quite a different form than the familiar soda soap used in the household. In contrast to this, the principal detergents encountered in sewage are salts of strong acids, which do not break down in weak solutions. The detergent acids, in contradistinction to the fatty acids in soap, are water soluble, and unlike soap, the detergents do not form insoluble lime salts. They do form insoluble salts with the cationic detergents, but, as previously pointed out, there is very little cationic detergent available.

Mechanics of Adsorption

The detergents used in the household seemingly dissolve in water like any salt. At extremely low concentrations they form true solutions. In the presence of salt and in useful amounts, the detergent molecules gather together in groups of 50 to 100 to form fairly well-defined aggregates, called "micelles." These micelles generally carry a charge, and for this reason are known as "colloidal ions." Deterging, or washing, depends on this micelle formation. When oils or dirt are present, minute amounts are taken into the inside of the micelle and so are suspended in solution.

The micelles associate themselves with surfaces of all kinds and in well-defined amounts. This is the property which gives them the name of "surface-active agent." The detergent molecules are then oriented so that the oil-soluble part of the molecule is attached to the water-insoluble material and the acid or salt part of the molecule is directed toward the water. This property of coating the surface is referred to as "adsorption." Adsorption removes detergent from solution, and since this adsorbed layer changes the surface which any water-insoluble material presents to the water, it completely changes the properties of that material. For instance, if a solid product tends to resist water, as soon as it becomes coated with a layer of molecules extending arms which grasp the water, it becomes wettable. The surface-active agents are, in fact, often referred to as "wetting agents."

The property of adsorption is not limited to liquids and solids. It is also effective with gases, and so the organic detergent may make possible the dispersion of a gas or air in water to give the characteristic "foaming" or "sudsing," provided that it is present in sufficient quantities.

The detergents do not have unlimited power. In the washing process (as, for example, in dishwashing), the common detergents suds profusely at the start, but as the washing proceeds the detergent is withdrawn from solution by the surfaces, such as food particles and fats. As the amount of dirt and oil increases, the detergent becomes overloaded and ineffective, at which time the suds disappear.

Factors Governing Adsorption

The amount of detergent adsorbed can be influenced. While all solid, gaseous, and liquid products which are insoluble in water tend to gather the detergent, the amount they gather changes significantly, depending on the amount of surface, its nature, the temperature, the detergent concentration, and the acidity or alkalinity of the solution. The amount adsorbed by any

surface is roughly proportional to the amount of surface.

Figure 3 shows how the amount of detergent adsorbed is affected by the concentration, in the case where cotton provides the surface. The values given in milligrams of pure organic detergent of the alkyl aryl sulfonate type, show the amount adsorbed from 100 ml. of solution by a small 5-g. piece of cotton cloth in 15 min. The values shown in Figure 3 are the values encountered in the relatively high concentrations required for washing, rather than in the very low concentrations encountered in sewage. It should be noted that while the amount of detergent adsorbed increases rapidly with increasing concentration, it is also true that a higher proportion of material actually in solution is adsorbed at the lower concentrations than at the higher concentration. Thus, at the washing concentration of 200 mg. per 100 ml. (2,000 p.p.m.), 16 mg., or roughly 8 per cent, is adsorbed; whereas at a concentration of 300 p.p.m., 25 per cent of the detergent is adsorbed by the same limited amount of surface.

Protein material is particularly effective for the adsorption of the anionic detergents. At the usual washing concentration, wool will remove 75 per cent of the alkyl aryl sulfonate type of detergent from 20 times its weight of neutral solution and 97 per cent of the same detergent from 5 times its weight of solution.

The amount of adsorption is greatly increased by lowering the pH. Figure 4, showing the adsorption by a small 5-g. piece of cotton cloth from 100 ml. of solution, indicates that the adsorption is substantially doubled (from 10 to 20 mg.) by reducing the pH from 7 to 4. This kind of increase takes place whether the adsorbing medium is cotton, as in this case, wool, glass, or other type of material.

Adsorption Removes Most of the Detergent from Sewage

It is evident from these properties that much of the detergent in raw sewage must be adsorbed, and that

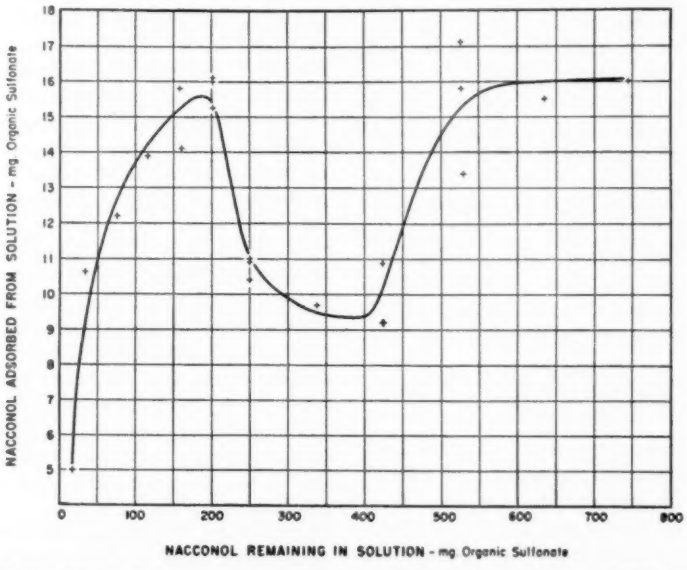

FIGURE 3.—Effect of detergent concentration on adsorption of Nacconol NR by cotton.

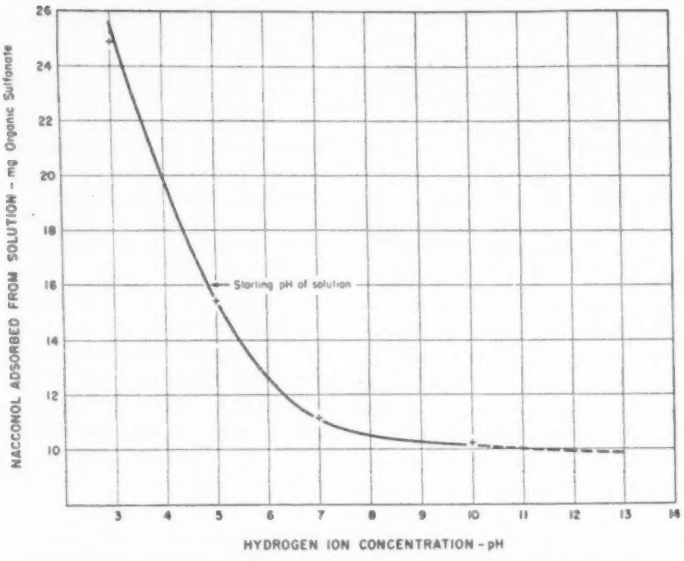

FIGURE 4.—Effect of pH on adsorption of Nacconol NR by cotton.

much of it must settle out with other solid matter. Preliminary attempts have been made to determine how much of the anionic detergent present is adsorbed. Much of the solid matter in sewage may be settled or filtered, and the detergent removed by that solid can be measured. It is more difficult to measure the detergent adsorbed by particles dispersed to the point where they pass through filters or remain suspended. About 30 to 50 per cent of the detergent in sewage may be removed with the solids, and it is probable that most of what remains is adsorbed by suspended solid matter. Adsorption has been recognized as a simple method for the removal of the active detergent from solutions.

Detergents Wash Bacteria into the Sewer

Operators of sewage disposal systems have been concerned with the effect of detergents on bacteria. This results in part from a very confused naming of products. The cationic detergents are powerful germicides, but because of the high cost and other factors, they have found no favor as washing agents. As a matter of fact, they are not used at concentrations required for washing, but in extremely low concentrations as antiseptics. In spite of this, they are still referred to as "detergents." A number of these so-called cationic "detergents" are used for rinsing glassware in restaurants, where germicides are required by public health regulations. There is no possibility of their being a factor in destroying bacteria necessary for waste disposal. In the first place, they are used in very small quantities. In the second place, the small amounts present are quantitatively precipitated from solution by the anionic detergents.

It is an established fact that the anionic detergents, which are commonly used, give much cleaner dishes from a biological standpoint. In fact, common washing operations with anionic detergents in the restaurant and in the dairy give almost sterile surfaces. Nevertheless, the spent dishwater has been shown to contain substantial numbers of bacteria (Table I).

TABLE I.—Residual Bacteria on Dinner Plates[1] and in Wash Water[2] after Restaurant Hand Dishwashing[3]

Test Point	Plates		Wash Water	
	Alk.[4]	NR[5]	Alk.[4]	NR[5]
Start	22	3	4,000	455
Middle	45	4	6,500	1,025
End	33	5	12,250	1,600

[1] Ten square inches.

[2] Per milliliter.

[3] Bacteria on exposed sterile plate control, 3.

[4] Sodium sesquicarbonate, 1.0 per cent solution.

[5] Mixture of sodium sesquicarbonate 80 parts, with Nacconol NR (anionic detergent of the alkyl aryl sulfonate type) 20 parts, 0.7 per cent solution.

Spent wash water from the household is diluted by other types of waste containing solids, which adsorb the anionic detergents from solution. In actual practice, the concentration of anionic detergents in household waste is reduced to the point where septic tanks function normally, as do many waste disposal plants. There are no well-established data to prove that the surface-active agents, as actually encountered in sewage, have been the cause of those difficulties in waste disposal which have been attributed to loss of bacteria.

Sudsing Action is Limited

When the detergents are suspected of being the cause of frothing in sewage disposal plants, the first reaction of the research chemist who makes detergents is: "I can't make detergents that will suds any longer than the housewife uses them."

The housewife uses these soaps and detergents until their washing action is substantially exhausted. Suds are important to her as an indication that she has active detergent. As the capacity of the detergent for removing soil is approached, very little sudsing action is left; with the addition of more soil, the suds disappear altogether. Suds are the housewife's measuring stick, and she uses it to avoid any wasteful use of either soap or detergent. When better detergents are made, the housewife will use less.

There is no established proof that sudsing, or in fact any other problem of the ordinary sewage treatment system, has been caused by anionic detergent. There have been a very few isolated instances of difficulties where some specific circumstance introduced excessive amounts of detergent into small local sewers, but the circumstances were so unusual that they are without general significance.

Although the commercial use of detergents is now 20 years old, they are still a much talked about washing material. For this reason, there has been a tendency to attribute any problem which might arise to the detergents, rather than to other less publicized factors affecting waste disposal. Detergent chemists are open-minded in these matters and alert to any difficulties which might be caused by any of the ingredients of the modern household washing material. If such difficulties do exist, the chemists of the detergent industry can be depended on to do their part in assisting those concerned with wastes treatment to solve them.

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DISCUSSION

By Willem Rudolfs

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The interesting and stimulating paper by Messrs. Flett and Hoyt shows the extraordinary increase in production of detergents from a few million pounds 10 to 12 years ago, to some 1,500,000,000 lb. sold at present. This enormous quantity of detergents eventually reaches the sewer, but, amazingly, about 1,200,000,000 lb. are used in homes. This means, in effect, that the use of detergents is widespread and that few, if any, sewage treatment plants will be without them.

Of the three groups of detergents—anionic, nonionic, and cationic—the first (anionic) is the most important because of the wide distribution, the large quantities sold, and the effects on sewage treatment processes.

The nonionic agents, representing only 3 per cent of the total sold, may be disregarded, except in cases where certain industrial wastes are received. Slugs of these detergents may produce a local problem. In general, the authors are correct that these agents "are not of concern in the ordinary waste disposal system."

The cationic agents are ordinarily also of little concern because of the relatively small quantities sold, their specific use, and their ability to combine with anionic detergents. Since they are used for specific purposes (for sanitizing, in restaurants, hospitals, etc.), they are more or less generally distributed. Their ability to combine with anionic detergents reduces the effect of the latter. Promotion of larger sales of cationic detergents may be in order.

Phosphates

The anionic detergents sold for household purposes are mixed with other compounds, primarily phosphates, sodium sulfate, common salts, and alkaline substances. The greatly increased production of phosphates, amounting to 775,000,000 lb. in 1951, coincides with the increase in production of detergents. From the standpoint of sewage treatment these figures have great interest. A series of papers (1) (2) (3) (4) in 1947 dealt with the effect of phosphates on sewage settling, chemical coagulation, activated sludge, digestion, and sludge dewatering. Raw sewage contains from 4.0 to 9.2 p.p.m. of phosphate, with an average of 5.2 p.p.m. expressed as P_2O_5. This corresponds to a daily production of about 2.5 g. per capita. If it be assumed that detergents are uniformly distributed, so that each family uses the same amount of detergents and equal quantities every day of the year, the amounts of sodium tripolyphosphate (260,000,000 lb. P_2O_5) and tetrasodium pyrophosphate (93,500,000 lb. P_2O_5), expressed as p.p.m. P_2O_5, would be about 2.93 g. per capita per day. Obviously, the assumptions are not correct, because not everybody uses the same amounts, nor consistently the same quantities every day. However, the 2.9 g. per capita per day would constitute the minimum average amount found in sewage.

Studies on the effect of phosphates in sewage treatment processes indicate that 50 to 70 per cent are removed during settling and 80 to 90 per cent in the activated sludge process. The phosphates do not affect the rate or degree of settling, but produce a considerably larger volume of sludge. Increased volumes of sludge are particularly noticeable with activated sludge.

When sewage is treated by chemical coagulation the presence of phosphates increases the required amounts of iron coagulants. Since most of the phos-

phates are removed by settling, they are transferred to the digesters. Phosphates cause a reduction in volatile matter destruction and retardation in decomposition and gasification. Even with only 25 per cent more phosphate than normally present in sewage, digestion is retarded and greater digestion capacities are required.

Phosphates are one of the chief controlling factors in sludge dewatering. The filtration time is increased, the sludge volumes are larger, and the filtration liquid is poorer when the amounts of phosphates are greater than normally present.

These statements of findings bring up the question whether the phosphates present in the packaged products sold are partly responsible for the difficulties encountered, rather than the organic detergents.

Digestion

Returning to the discussion on detergents as such, the authors explain that the detergents found in sewage form fairly well-defined aggregates or micelles and that deterging or washing depends upon this micelle formation. "When oil or dirt is present, minute amounts are taken into the inside of the micelle and so are suspended in solution." These particles are extremely small, settle only slowly, and are the reason why part of these finely divided particles pass through settling units and increase the load on trickling filters. However, it is extremely doubtful that the micelles formed in rather concentrated solutions during laundering, dishwashing, etc., remain when diluted in sewage. There is something like processes of desorption and breaking down of the fragile micelles. Desorption and breakdown of micelles are of some consequence, and perhaps of decided advantage in sewage treatment, as shown later.

Detergents are good wetting agents. This should aid in removal of oily and other floating materials. Hence, in practice, the use of detergents should cause less scum on clarifiers and possibly less scum formation in digesters.

The authors state that 400,000,000 to 500,000,000 lb. of pure anionic detergent goes into the sewer. Suppose their statement is correct, that "adsorption removes most of the detergents from sewage"; or, to be more specific, that actually 50 per cent of the detergent in sewage is removed with the solids. What does that mean in practice?

If, again, it is assumed that the anionic detergents are uniformly sold and used in the same quantities every day, the average daily use of this organic detergent would amount to 3.3 to 4.0 g. per capita. However, only half of the detergents would be removed from the sewage, or 1.65 to 2 g. per capita per day.

Suspended solids production amounts to about 0.2 lb. per capita per day. With a removal of 70 per cent by settling, the sludge produced amounts to about 63 g. per day. Hence, with half of the detergents left in the liquid portion passing through the settling tank, the minimum amount of detergent present in the dry settled solids would be 2.6 to 3.2 per cent on a dry solids basis.

Putting it differently, the authors state that, by actual determination, 1 to 15 p.p.m. detergent has been found in raw sewage, or 8.3 to 124 lb. per m.g., or the equivalent of 0.37 to 5.6 g. per capita. Since only half of the detergent would find its way into the sludge, the quantities in the sludge would be between 0.2 and 2.8 g. per capita, or 0.3 to 4.4 per cent on a dry solids basis. The average of the two values would be 2.3 per cent. It is obviously difficult to determine exactly the quantities of detergent in sewage, but the average amount approaches the values given for the total sales of anionic detergents.

Where do all these data lead to? Carefully controlled experiments have shown that 0.2 per cent of anionic detergents on a dry solids basis present during digestion has no effect; that

with 1 per cent there is some retardation, but no material effect; but when the percentage of detergent becomes higher, the effects become serious.

If the implication by the authors were correct, that no desorption and no dispersal of the adsorbed detergent took place, and none of the detergent left the digesters with the supernatant liquor, most digesters would be in a poor condition, because with a daily addition of 60 lb. to a digester handling the sludge produced from 1 m.g., the detergent accumulation in the digester during a 30-day digestion period would amount to 1,800 lb. of detergent.

Bacteria

The authors state that there is "no possibility" of cationic detergents "being a factor in destroying bacteria necessary for waste disposal," and that anionic detergents have "no demonstrated effect on the bacteria," because dishwater still contains bacteria and this water is further diluted in the sewer by other types of wastes.

Those concerned with sewage treatment are not much interested in most of the types and numbers of bacteria present in raw sewage. They are, however, much interested in those groups of well-established organisms in the purification and gasification processes, particularly nitrifying bacteria, slime-producers, and methane-producing organisms. The effect of different types of detergents on sewage microorganisms is discussed by Manganelli and Crosby (5, see page 262). Considerable doubt exists as to the wisdom of making a sweeping statement that there is no possibility of detergents affecting the activities of bacteria necessary for waste disposal.

Frothing

The authors are at pains to explain that the housewife uses soaps and detergents until the washing action is substantially exhausted, as measured by the disappearance of "suds." They state further that "it is true that nobody has been able to prove that sudsing, or in fact any other problem of the sewage disposal systems, has been caused by anionic detergent, except in a very few isolated instances where some specific circumstance introduced large amounts of active detergents into small local sewer systems." It is probably true that nobody has been able to trace frothing at sewage plants directly to detergents, but there seems to be considerable circumstantial evidence that frothing is more pronounced since the advent of increased detergent sales.

Manufacturers, users, and sewage works operators are all interested in detergents. Manufacturers want to sell them, housewives like to use them, and sewage plant operators must take them as they come. There is little use in blaming detergents for all difficulties at sewage plants; likewise, brushing aside any possible effect leads nowhere. It is gratifying to the writer that industry, investigators, and plant operators want to know the facts, collaborate to secure the facts, and may even conduct cooperative research, pool information, or at least have a frank interchange of opinions. As soon as the difficulties to be encountered are known, methods will be devised to overcome them.

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ACTION OF DETERGENTS IN SEWAGE TREATMENT—A STUDY BY INDUSTRY *

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For some time there has been concern and speculation in some quarters of the sewage treatment field about possible effects synthetic detergents might have on sewage treatment. The most frequent speculation about problems they might cause has concerned the question of frothing of aeration tanks in the activated sludge process. This is a natural association, because suds are more commonly associated with washing products than with practically anything else—including beer. In some quarters this speculation on possible relationship between frothing and detergents has taken on the reputation of a fact, so often has it been repeated.

It seemed desirable to establish whether there might be any direct relationship between frothing and increased use of detergents. Since it seemed inconceivable that such high dilutions of detergents as those found in domestic sewage could make suds in such dirty water, an obvious starting point was to try to create froth deliberately in the activated sludge process by adding detergents in amounts well above what might ever find its way into sewage, even with a greatly increased use of synthetics.

Early Tests at San Antonio

Some full-scale tests were made cooperatively with the San Antonio, Tex., sewage treatment plant. It would be superfluous to describe that work in detail here, as it has already been published and all the details are available (1). However, it formed the background for additional work done since that time, and a brief review may be helpful.

Wells (1) had found that he could create froth at will by reducing the recycled solids in the aeration tanks. He also found that he could keep froth from forming, whether or not detergent was added, if mixed liquor solids were kept reasonably high—above 1,400 p.p.m. for his particular conditions. Detergent concentrations as high as 250 p.p.m. were tested at various mixed liquor suspended solids concentrations, with the same results. The plant is well designed to do such testing work, as it has seven parallel aeration tanks, each of which can be individually controlled. In the work reported, one tank was used for test purposes, the other six acting as the control. The detergent concentrations reported were in addition to the detergent normally present in the sewage.

It should be emphasized that it was not possible to make the aeration tanks froth by adding synthetic detergent. It was easy to make them froth by reducing solids level without adding detergent. In fact, even at marginal levels for the San Antonio plant—that is, levels where froth frequently starts to form because of low solids conditions—it was impossible to make the frothing any worse by the addition of synthetic detergent.

The outcome of these tests is in line with general experience in the detergent field, which has always been that it is impossible to make suds with such dilute solutions of the ordinary household synthetic detergents in such dirty water. However, the tests had been carried out only under conditions pre-

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vailing at one plant, and it seemed worth while to repeat these tests on another type of equipment to see if the same principles held for other conditions. There are many relatively small mechanically-aerated activated sludge plants in the country, so it was decided to try some tests on one of those.

Plant Tests on Mechanical Aeration

A mechanically-aerated activated sludge plant located at Bryan, Ohio, seemed to be about what was needed for the tests. Moreover, Superintendent Phillips was very much interested in expanding the existing knowledge of the subject. Accordingly, plans were laid for some tests.

Having had the San Antonio experience, it was decided that the necessary information could be obtained by adding synthetic detergent at the rate of 100 p.p.m. based on the incoming primary effluent. This, of course, was in addition to the synthetic normally in the sewage. Probable concentrations of synthetic detergent in sewage were computed by Wells (1). These computations add up to an average concentration of soaps and synthetic detergents together of slightly over 50 p.p.m. (of the finished products as sold) in sewage. Probably at present a little less than half of this is synthetic detergent, so that a 100-p.p.m. concentration over and above that normally in the sewage represents an adequate excess over what should ever be found from normal use. By picking Monday, washday, for the test, it was obvious that with the extra added detergent there should be far more total synthetic present than any treatment plant would ever be likely to see from domestic sewage. The addition started before noon on Monday and continued for 6 hr., so that the addition coincided with Monday's peak washday flow.

Figure 1 shows a layout of the plant. The influent from primary sedimentation enters the aeration tanks at point A and goes through the six tanks in series, as shown by arrows. Then the mixed liquor flows to final sedimentation before discharge to the creek.

Figure 2, showing the aeration tanks before the addition began, shows that there was no froth. This particular plant normally operates at about 800 p.p.m. suspended solids in the mixed liquor and seldom has any froth forma-

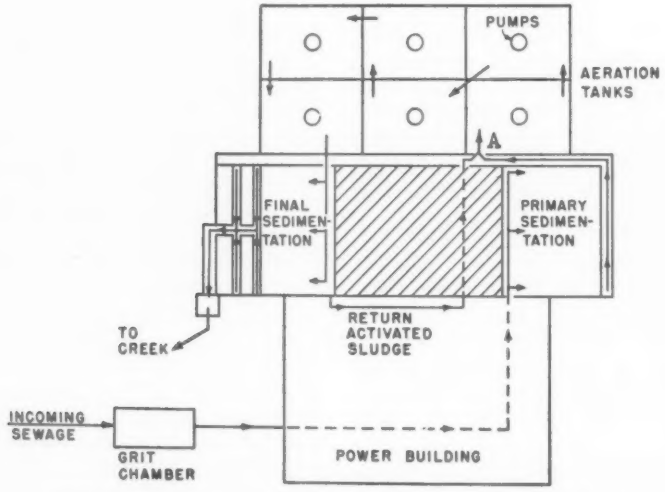

FIGURE 1.—Layout of Bryan, Ohio, sewage treatment plant.

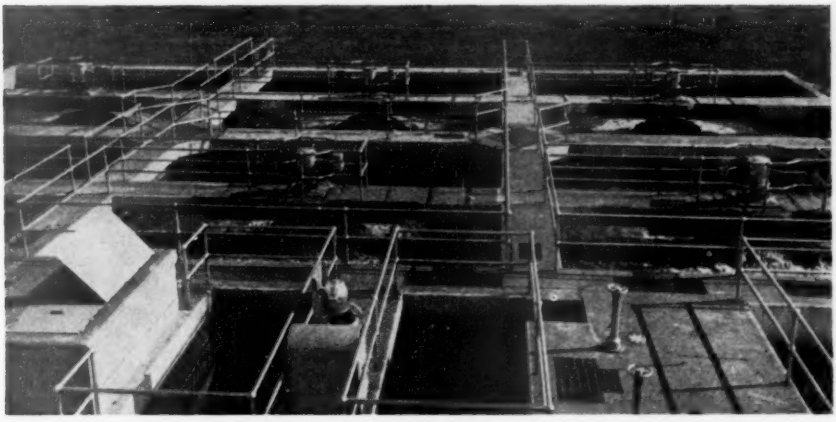

FIGURE 2.—Aeration tanks before addition of synthetic detergent. Normal operating suspended solids (800 p.p.m.)

tion except when dairy or cannery wastes are heavy.

Figure 3 shows the same tanks after 5 hr. of addition of synthetic at the rate of 100 p.p.m. based on the rate of flow of the influent to the aeration tanks. There still is no froth.

Figure 4 is a close-up view of the first tank of the series after 5 hr. of addition of synthetic detergent at the rate of 100 p.p.m. No froth.

Figure 5 shows the last tank at about the same time. The other four looked the same, as they did all through the test. As had been the case at San Antonio, it was impossible to make the aeration tanks froth by adding synthetic detergent, even in relatively large amounts.

As an additional part of the test, it was decided to see if reduced solids would cause froth trouble in this plant as had been shown to be the case at San Antonio. Figure 6 shows the effluent sluiceway from the aeration tanks under normal operating conditions. The solids were then dropped to around 200 p.p.m., from their normal 800 p.p.m., with the froth build-up shown. There was no synthetic detergent added. This sluiceway was free of froth all during the addition of

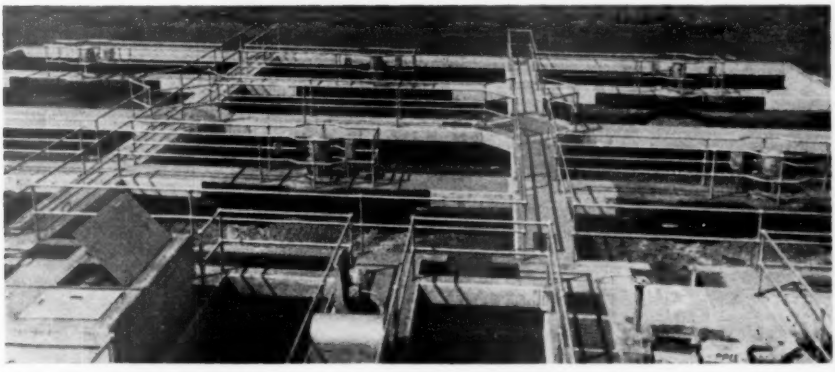

FIGURE 3.—Aeration tanks after 5 hr. of continuous addition of synthetic detergent at the rate of 100 p.p.m.

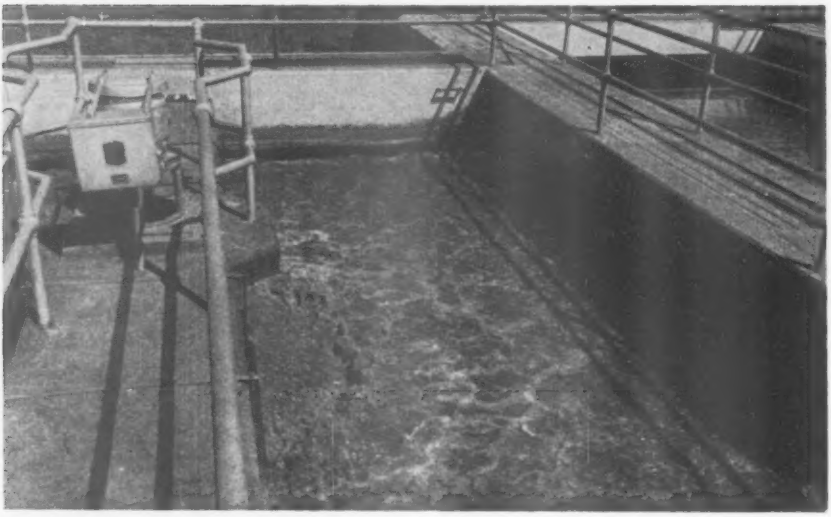

FIGURE 4.—First tank of series after 5 hr. of continuous addition of synthetic detergent at the rate of 100 p.p.m.

synthetic detergent, the froth only occurring when the solids were lowered.

This work had been undertaken as a check on the San Antonio tests. Reduction of the solids reacted just as it had at San Antonio in that it caused frothing. Also as at San Antonio, the froth disappeared when the solids were

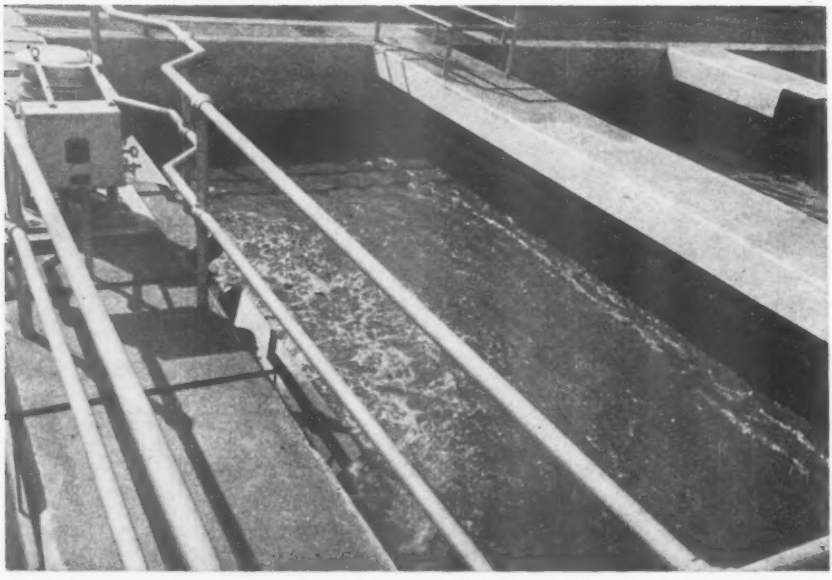

FIGURE 5.—Last tank of series after 5 hr. of continuous addition of synthetic detergent at the rate of 100 p.p.m.

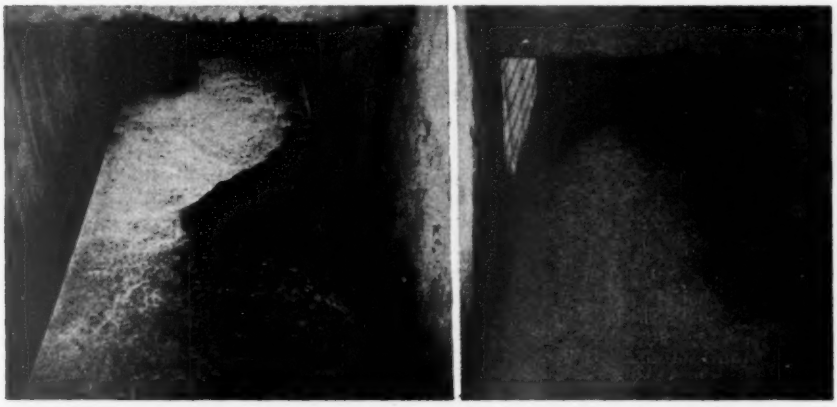

FIGURE 6.—Effluent sluiceway under normal operating conditions (left) and with reduced aeration tank solids (right). Under neither condition was detergent added to the aeration tank influent.

again raised. The frothing from lowered solids was not as bad as it has been there. The symptoms were the same, but different in degree.

There were no apparent effects on other aspects of the operation from the addition of synthetic detergent, and in this respect the experience at Bryan was again like that at San Antonio.

Other Plant Studies

In the work done to date, the picture is quite consistent. It has not been possible to make froth on aeration tanks by adding relatively large quantities of synthetic detergent, whether recycled solids were at normal levels or at marginal levels with regard to frothing. In connection with this problem, case histories have also been collected on 10 plants, most of which were having or had encountered frothing trouble at one time or another. All the plants where it has been possible to establish the conditions during periods of serious frothing, have also been carrying relatively low solids. Just as consistently, those which normally do not have frothing troubles do get into trouble if they carry their solids at low levels, where such conditions have been tried.

It should be mentioned that this observation is not new. Edwards (2) and others, too, in conversations, have pointed to low solids as causing frothing conditions for many years.

There is no pretense at knowing what makes froth at low solids. Neither is it understood why some plants can operate without foam at lower solids levels than others. To speculate for a moment, it seems quite possible that the oxidation products formed during low solids operation may be different from those formed under high solids conditions. A great many things can stabilize froth or suds. Some proteins, and glucocides like the saponins, for instance, form the most stable foams in existence. The thought that this frothing may be caused by some such oxidation products has some support in the pattern which frothing takes when it does occur. In the author's experience, in all the instances where froth occurs, it does not occur in the earliest stages of aeration at the influent end of the aeration pass, even though the agitation and aeration there is more than violent enough to form a froth, if the froth-making substance existed at that point. This is true of all the full-scale operations seen, and also has been true of a limited number of laboratory-scale

aerations made. The unaerated influent as it comes into a frothing aeration tank from primary sedimentation will not foam to amount to anything, even under most violent agitation; but after it has passed on down the tank and has been aerated for 2 or 3 hr., it can be made to foam. Detergents and other sudsing agents simply do not act that way. If they are present in sufficient quantities they will suds right away—they do not require hours of agitation or aeration—and if there is not a high enough concentration present to make a stable froth immediately, no amount of agitation or aeration will make one.

These observations make it appear that the froth-making agent is actually manufactured right in the tank by the oxidation process. This idea is not new either. Eckenfelder and Hood (3) have pointed out that "Research discloses that foaming is probably more frequently encountered at a stage of oxidative purification rather than in the presence of detergents in their present concentrations." Of course, variations in the composition of sewage can be quite great, and equipment and available facilities for its disposal are quite varied from plant to plant. Consequently, no one problem or its cure is going to be exactly the same for everyone, and each plant may require somewhat different methods to control particular problems. So far, no instance is known where solids adjustment has been tried where it has not controlled any troublesome frothing problem that may have existed. To limit the conclusions to the facts these studies have shown, it does not appear that commonly sold household detergents play any important part in practical frothing problems encountered in the treatment of sewage by the activated sludge process.

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DISCUSSION

BY W. N. WELLS

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Without the cooperation of Mr. Gowdy and the Procter and Gamble Company the experimental work at the San Antonio plant would have been impossible, as the budget simply did not allow for the purchase of 2,800 lb. of Tide. Also their ability to extend the experimental work to other plants has aided materially in the clarification of this problem.

The obvious conclusion to be drawn from Mr. Gowdy's studies is that synthetic detergents are not responsible for froth on aeration tanks. Although the writer is not prepared as yet to go along 100 per cent with this conclusion, it is believed that the burden of proof now lies with those who take the opposite view.

Why has it been so generally accepted that detergents cause froth on aeration tanks?

First, the froth on aeration tanks has a very similar appearance to the suds obtained by the use of synthetic detergents around the household. The conclusion of plant operators was that this same foam producer was the cause of froth in the aerators.

The second and perhaps more important reason hinges on a trend in sewage treatment practice coincident

with the increased consumption of synthetic detergents. No one will deny that there has been a constant increase in the use of detergents since the late 1930's and no one will deny that the frothing problem has increased since the late 1930's; however, during this same period activated sludge plants have been operated at lower and lower concentrations of solids in the aeration tanks. Which is to blame: increased use of detergents or low solids? Any person who has operated a conventional activated sludge plant has had the experience of froth formation when the plant is first put into operation or when a new sludge is being developed. Invariably the plant will go through a period of frothing at low solids concentrations. Is it any wonder that the new high-rate, low-solids units froth constantly?

What then is responsible for froth formation and why does increasing the solids in the aeration tanks eliminate frothing? These are good questions, for which answers are still being sought. As pointed out by Mr. Gowdy, there is some evidence to indicate that under certain conditions of aeration there is formed a material or compound which causes frothing. The following are a few added observations made at the San Antonio plant:

1. The primary settled sewage flows first into an aerated distribution channel before mixing with returned sludge and passing into the aeration tanks. Frothing has never been noted in this distribution channel, although the sewage is vigorously agitated at this point.

2. When frothing takes place, it occurs toward the effluent end of the aeration tanks, indicating that something causing frothing is being formed during the first period of aeration. This something finally reaches a concentration sufficient to cause frothing only after 2 or 3 hr. of aeration.

3. It has been observed that when the solids are lowered in one tank and frothing takes place, within 12 to 24 hr. the other tanks in parallel with the frothing tank will begin to show signs of froth, even though the solids are above the "safe" level. This would indicate that a substance is being formed in the low solids tank which is contaminating the other tanks through the returned sludge.

4. When the aeration tanks are frothing vigorously, the material causing frothing carries over into the final tanks and frothing takes place in the effluent channels and even several miles down the San Antonio River at a small dam in the river.

Although no quantitative data have been obtained to support these observations, it is believed that the evidence is sufficient to justify further work along these lines.

EFFECT OF DETERGENTS ON SEWAGE MICROORGANISMS *

By Raymond Manganelli and Edwin S. Crosby

Rutgers University, New Brunswick, N. J.

Microorganisms and their diverse activities play an essential and fundamental role in the field of sewage treatment. A knowledge of their physiological and biochemical characteristics and interrelationships serves in regulating and directing their activities for useful purposes. Anaerobic organisms are generally utilized in the stabilization of organic sludges, while aerobic fauna and flora are important in processes such as trickling filters and activated sludge, which cause a high degree of removal of pollutional and putrescible matter from liquids. With the application of this basic knowledge, sewage treatment units may be operated under optimum conditions to promote efficient decomposition of complex substances, resulting in rapid purification.

The ubiquitousness of microorganisms not only enhances the beneficial aspects, but also introduces perpetual problems, such as slime growths in sewers and sewage treatment devices, with attendant fouling and corrosion of equipment.

Utilization of biological processes is not without difficulties. Any substance or environmental factor that retards the growth or a particular activity of the organism, reduces the efficiency of the device for treatment. At the same time, an undesirable condition may be ameliorated.

Entering a sewer, and ultimately a sewage treatment plant, are a great multitude and variety of materials; products of industrial and household functions. Some of these materials may be stimulatory and others harmful to biological life in sewers and treatment plants. One series of such compounds is the synthetic detergents. Increasing production and extensive usage have drawn the attention of many workers to the possible effects of these agents on treatment systems and processes.

In a previous paper (1), the principal influences of detergents on sewage oxidation, chemical coagulation, sludge digestion and filtration, chlorination, coliform organisms, and aeration were examined. The present paper deals briefly with two phases of the many-faceted problem, as follows:

1. Evaluation of the effect of detergents representing the three main types on slime growth in sewers.
2. Effect of these agents on activated sludge with respect to (a) repeated additions on oxidation of sewage, (b) interacted detergents on oxidation of sewage, and (c) repeated additions on the nitrification capacity of activated sludge.

The surface active agents employed, in a range of concentrations expected in sewage, were Nacconol N.R. (anionic), Tween 80 (nonionic), and Ceepryn (cationic).

Effect on Slime Growth in Sewers

A series of laboratory experiments was conducted to determine the effect of detergents on slime growth in sewers. The action of the detergents was based on the relative increase or decrease in the weight of film attaching

* Paper of the Journal Series, New Jersey Agricultural Experiment Station. Presented at 25th Annual Meeting, Federation of Sewage and Industrial Wastes Assns.; New York, N. Y.; Oct. 6–9, 1952.

TABLE I.—Effect of Detergents on Slime Growth

Detergent		Weight Increases[2] (mg./sq. dm.)	
Agent	Conc.[1] (p.p.m.)	6 days	12 days
Nacconol NR	10	3.7	14.5
	25	3.2	13.2
	50	3.0	12.7
	100	1.5	7.0
Ceepryn	10	0.5	2.0
	25	0.5	2.2
	50	1.2	3.0
	100	0.7	3.2
Tween 80	10	3.2	17.2
	25	2.7	16.7
	50	1.7	15.5
Control	0	1.7	11.0

[1] As p.p.m. on basis of total package product.
[2] Average weights of 4 slides.

to submerged glass slides moving slowly through sewage.

Representatives of three main types of surface active agents (anionic Nacconol NR, nonionic Tween 80, and cationic Ceepryn) were added daily in concentrations varying from 10 to 100 p.p.m. based on total package product.

The results, depicting weight increases on the basis of milligrams per square decimeter for 6- and 12-day immersion periods, are summarized in Table I. It is evident (Figure 1) that the weight increases followed a similar trend for both immersion periods.

All concentrations of cationic Ceepryn inhibited growth below control levels at both 6- and 12-day periods. All concentrations of the nonionic Tween 80 produced growth at or above the control level, tending to decrease toward the control level with increasing concentrations. Concentrations from 10 to 50 p.p.m. (40 per cent active matter) Nacconol stimulated growth above the control level, the degree of stimulation decreasing with increasing concentrations. The highest concentrations (100 p.p.m.) of Nacconol retarded growth below control levels at both 6- and 12-day intervals.

It is estimated that slime growing actively on one-third of the surface of a sewer 36 in. in diameter and 1 mi. in length (internal area 23.1×10^4 sq. dm.) will usually produce 30 cu. ft. of slime in 6 weeks. An increase of ½ to 2 times this value may be produced by the presence of low concentrations of anionic and nonionic detergents, whereas slime volume may be reduced by ⅓ in the presence of cationic agent.

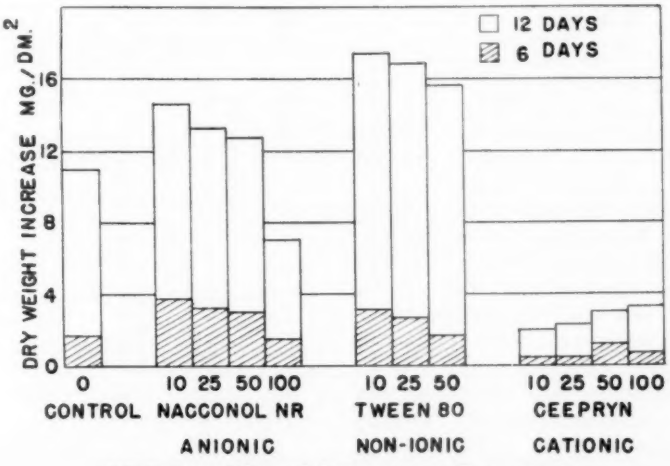


FIGURE 1.—Effect of detergents on slime growth.

Microscopic examination of films grown on glass slides submerged in sewage indicates that the primary film-forming organisms are largely Gram-negative cocco-bacilli. Inhibition of these primary organisms is significant in preventing or stimulating secondary organisms. In domestic sewage this basic film is generally formed within 3 or 4 days. The moisture content of slimes from raw sewage is about 95 per cent and the ash approximately 20 per cent of the dry weight, but in some cases the ash content may be as high as 36 per cent, as the result of adsorption of inert substances.

Since the predominant types (anionic and nonionic) of detergents, in quantities expected in sewage, stimulate slime growth rates, an over-all increase in slime growth in sewers may be anticipated. Under such conditions more frequent slime discharge would reach the treatment plant, creating difficulties for the units concerned. High concentrations of these detergents in industrial wastes, or presence of cationic agent, may result in cleaner sewers. The problem with regard to the effect on microorganisms is then projected to the biological processes of the treatment plant.

Effect of Repeated Additions on Activated Sludge

In a previous paper (1), the effect of a single addition of detergents on oxygen uptake of activated sludge in the presence and absence of sewage was described. Since detergents are continuously present in sewage, the effect of repeated additions of these agents on the biological purification of sewage by activated sludge, based on B.O.D. removals and final turbidity of the effluents, was studied. Sufficient oxygen for the mixed liquor containing 1,000 p.p.m. activated sludge was assured by employing continuous and violent mechanical shaking. Some of the results obtained during six passages of detergent in concentrations of

TABLE II.—Effect of Detergents on Purification of Sewage by Activated Sludge

Passage No.	Aeration Time (hr.)	Control Effluent			Nacc. Effluent[1]			Tween 80 Effluent[1]			Ceepryn Effluent[1]		
		B.O.D. (p.p.m.)	B.O.D. Red. (%)	Turbidity (p.p.m.)	B.O.D. (p.p.m.)	B.O.D. Red. (%)	Turbidity (p.p.m.)	B.O.D. (p.p.m.)	B.O.D. Red. (%)	Turbidity (p.p.m.)	B.O.D. (p.p.m.)	B.O.D. Red. (%)	Turbidity (p.p.m.)
1	6	38.5	66.5	50	99	13.9	140	41	64.5	44	86	28.2	145
2	18	23	80.0	31	96	16.5	160	22	80.7	29	48	59.2	244
3	6	20	87.3	23	66	57.9	136	25	84.0	20	74	53.0	240
4	18	10	90.5	29	37	64.5	134	13	87.5	28	52	49.0	264
5	6	13	85.9	26	41	55.5	130	14	84.7	25	39	57.6	290
6	18	17	81.5	25	30	57.4	110	17	81.5	25	50	45.7	285

[1] Effluent after treatment following addition of 100 p.p.m. of active matter.

100 p.p.m. (active matter) are summarized in Table II. B.O.D. removals and turbidity remaining in the effluents of the control and the sewage containing Tween 80 were approximately equal. However, the purification capacity of activated sludge was impaired by the repeated additions of the anionic and cationic detergents. The B.O.D. reduction was, at best, only 60 per cent of that produced by the control; the turbidity values of the effluents from the anionic Nacconol samples averaged 5 times greater and those of the Ceepryn treated sample were about 8 times greater than the control values.

Oxygen uptake of the activated sludge itself, after only 6 passages of Nacconol and Ceepryn, was substantially suppressed (Figure 2), whereas an increase in oxygen utilization for Tween 80 treated sludge indicated presence of residual oxidizable detergent. The oxidation of sewage by these detergent treated sludges followed the same pattern exhibited in the case of oxygen uptake by the sludges alone.

Microscopic examination revealed no difference between the active biological communities of the control sludge and the Tween treated sludge, but the sludges which received Nacconol and Ceepryn additions displayed a lack of protozoal and higher forms, with condensation of protoplasmic constituents within the sludge particles.

Repeated passages of surface-active agents of the Tween 80 type, which are nonionic in character and biologically oxidizable, have no effect on activated sludge itself or on its purification capacity. Repeated passages of high concentrations of anionic Nacconol and cationic Ceepryn cause rapid deterioration of the sludge and its oxidizing ability; the effect being more pronounced with the cationic detergent. Low concentrations of these agents, when present continuously, induce comparable results. Progressive impairment of activated sludge and its

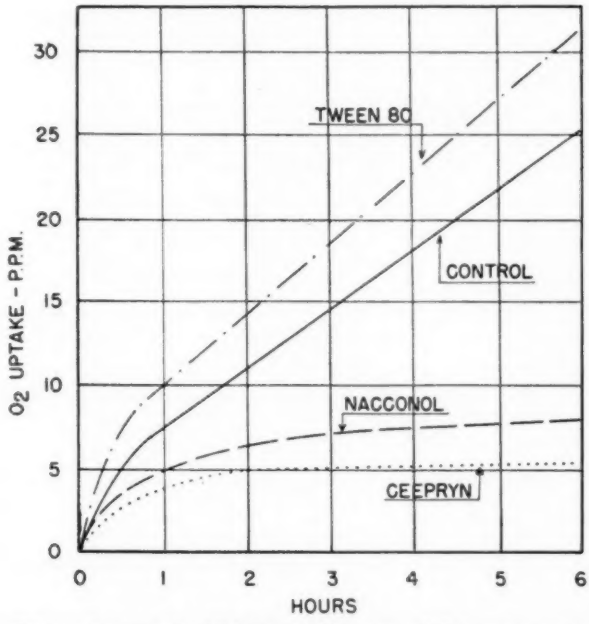


FIGURE 2.—Effect of repeated additions of 100 p.p.m. of detergents on oxygen uptake of activated sludge.

purification capacity by repeated additions of Nacconol and Ceepryn under laboratory conditions precludes the possibility of acclimatization of sludge organisms to such agents.

Effect of Detergent Combinations on Activated Sludge

Interaction of most anionic and cationic detergents causes formation of an insoluble complex, which precipitates or remains in suspension, depending on the presence of excess quantities of either reactant.

To determine whether the product of such an interaction was inhibitive to sewage oxidation by activated sludge organisms, anionic Nacconol NR and cationic Ceepryn were mixed with sewage and activated sludge (1,000 p.p.m. in mixed liquor) in equivalent concentrations of 0, 25, 50, and 100 p.p.m. so that the total quantity of detergent present would be 100 p.p.m. The results of the first 6 hr. of sewage oxidation (Figure 3) show again that Nacconol, and to a greater extent Ceepryn alone, caused suppression of sewage oxidation.

Addition of Nacconol and Ceepryn combinations resulted in diminished retardation of oxidation in 6 hr.; the retardation was overcome in 24 hr. when Nacconol concentrations were equal to or greater than the amounts of Ceepryn present. Increasing quantities of unreacted Ceepryn exhibited increasing and persistent suppression of oxidation.

In a second series of experiments, 25 to 100 p.p.m. of Nacconol were added to 100 p.p.m. of Ceepryn. The results (Figure 4) show that as the concentration of Nacconol added to the cationic agent decreased, the determent of oxidative activity of the sludge organisms became more pronounced.

The effect of stoichiometric combinations of detergents on sewage oxidation (on the basis of B.O.D. of sewage exerted) by activated sludge previously treated three times with these

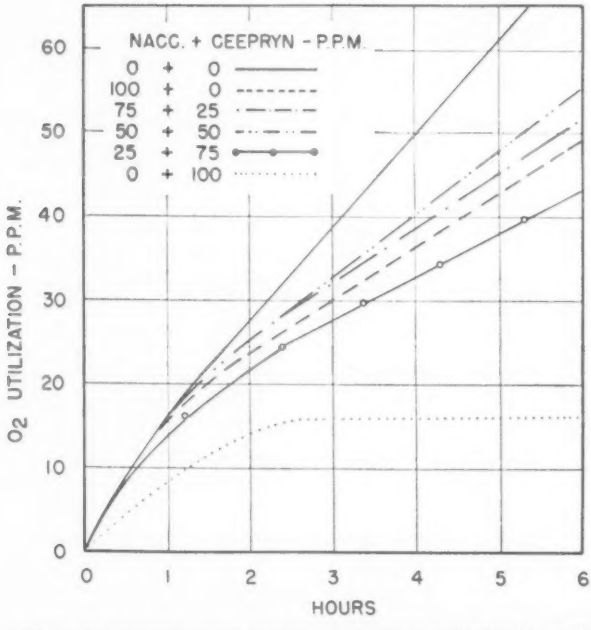


FIGURE 3.—Effect of detergent combinations on sewage oxidation by activated sludge.

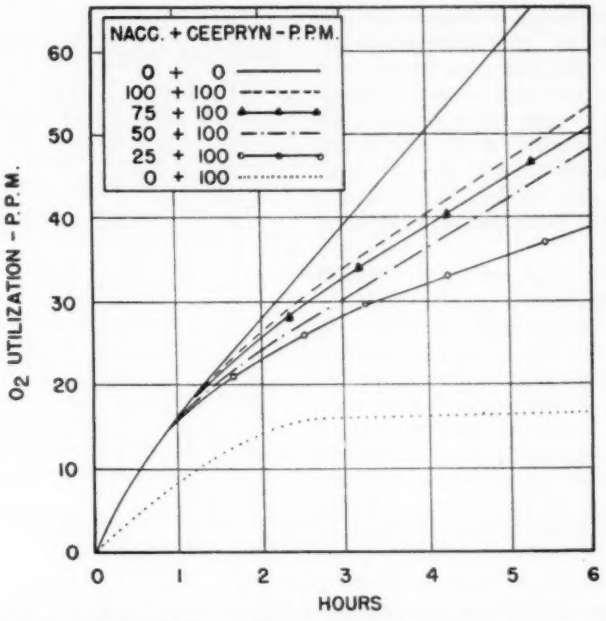


FIGURE 4.—Effect of Nacconol additions to 100 p.p.m. Ceepryn on oxidation by activated sludge.

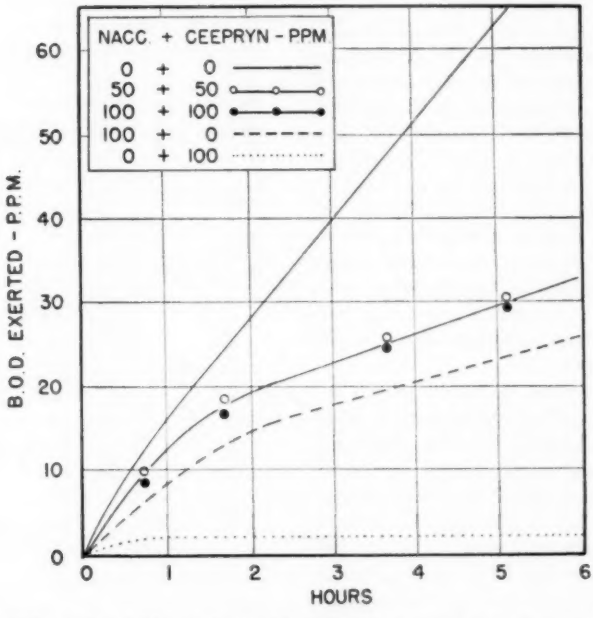


FIGURE 5.—Effect of stoichiometric combinations of detergents on sewage oxidation by activated sludge.

mixtures is shown in Figure 5. The B.O.D. exerted was diminished approximately 50 per cent at the end of 6 hr. by both stoichiometric combinations of 50 and 100 p.p.m. of each agent. Treatment with 100 p.p.m. Nacconol alone reduced the oxidation to 40 per cent of the control, and a more marked reduction was exhibited by Ceepryn.

Detergent complexes are the form in which these agents would probably exist under actual field conditions. It is significant, therefore, that interaction of anionic and cationic types decreases the inhibitory action of each detergent. Also, the concentration of the unreacted agent is more important than the total concentration of detergents present. It may be expected that any materials which reduce the concentration of "free" detergent will in turn reduce the deleterious effect of such agents on biological processes.

Effect on Nitrification Capacity of Activated Sludge

Nitrification in the activated sludge process serves as a yardstick designating the progress of decomposition and the degree of oxidation of pollutional matter. Organic nitrogenous compounds are broken down biologically to ammonia, which is then oxidized by specific autotrophic bacteria in two distinct steps: first to nitrites and subsequently to nitrates. Activated sludge usually contains an ample population of nitrifying organisms capable of carrying out these reactions rapidly and simultaneously.

Experiments were conducted to determine the effect of repeated additions of detergents on the nitrifying organisms and consequently on the nitrification capacity of activated sludge. Nacconol NR, Ceepryn, and Tween 80 in various concentrations of 10 to 100 p.p.m. were added twice daily to activated sludge (1,000 p.p.m.) and sewage mixtures for a period of 7 days (13 passages). The samples were aerated

TABLE III.—Effect of Nacconol NR on Nitrification by Activated Sludge

Passage No.	Sewage NH_3-N Added (p.p.m.)	Control		Nacconol NR									
				10 P.P.M.		25 P.P.M.		50 P.P.M.		100 P.P.M.			
		NH_3-N (p.p.m.)	NO_2-N (p.p.m.)	NH_3-N (p.p.m.)	NO_2-N (p.p.m.)	NH_3-N (p.p.m.)	NO_2-N (p.p.m.)	NH_3-N (p.p.m.)	NO_2-N (p.p.m.)	NH_3-N (p.p.m.)	NO_2-N (p.p.m.)	NH_3-N (p.p.m.)	NO_2-N (p.p.m.)
1	7.00	0.05	0.020	0.05	0.05	0.10	0.05	0.15	0.25	0.25	12.3	0.25	6.00	7.75
3	14.00	4.25	0.045	4.25	4.50	5.50	11.50	8.50	12.50	20.00	3.0	20.00	0.25	0
5	18.75	4.25	0.030	4.25	12.00	8.50	9.00	21.25	0.25	21.20	0	21.20	0.02	0
7	17.50	0.10	0.025	1.40	10.00	8.75	4.50	16.25	0.05	16.25	0	16.25	0.02	0
9	32.50	13.00	0.045	10.00	10.00	37.50	1.20	37.50	0.02	40.00	0	40.00	0.02	0
11	13.00	5.00	0.020	6.00	6.00	16.25	0.55	16.25	0.01	16.25	0	16.25	0.01	0
13	13.00	0.05	0.015	6.50	6.00	14.50	0.075	13.75	0.02	12.50	0	12.50	0.02	0

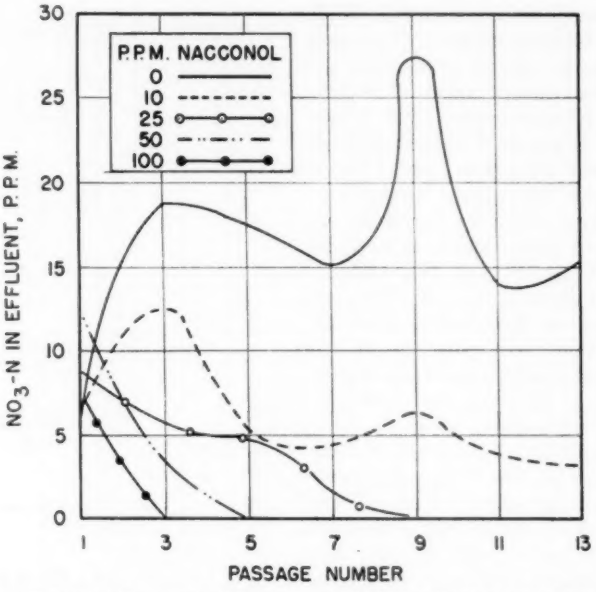


FIGURE 6.—Effect of Nacconol additions on NO_3-N production by activated sludge.

by continuous mechanical shaking at 20°C. to insure adequate oxygen diffusion, which would be impossible by compressed air bubbling because of excessive frothing.

The data obtained with repeated additions of anionic Nacconol are summarized in Table III. It was found (Figure 6) that nitrate production was inhibited by additions of Nacconol in all concentrations in a range of 10 to 100 p.p.m. (active matter). This resulted in an accumulation of NO_2–N, which subsequently diminished as de-

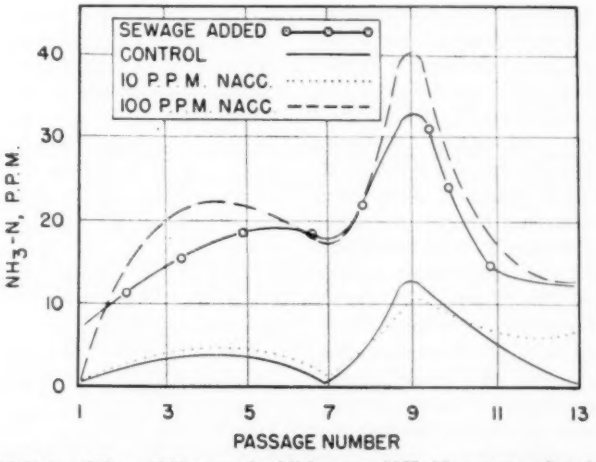


FIGURE 7.—Effect of Nacconol additions on NH_3-N content of activated sludge effluents.

tergent dosages were continued. With increasing concentrations of Nacconol, the decrease in nitrite production occurred at an earlier stage. The production of nitrates ceased after 9 passages with 25 p.p.m. Nacconol, after 5 passages with 50 p.p.m., and after 3 passages with 100 p.p.m. Nacconol.

Interference with the oxidation of ammonia and nitrite induced a rise in the NH_3–N content of the effluent. The concentration of NH_3–N remaining increased above the control level on the sixth day (11th passage) of 10-p.p.m. Nacconol addition. With higher detergent concentrations, accumulation of NH_3–N commenced after the first detergent addition and gradually increased above the level originally present in the sewage added. Figure 7 depicts the NH_3–N concentration present in the effluents of the control and Nacconol dosages of 10 and 100 p.p.m. The NH_3–N content of the effluents employing the intermediate detergent concentrations generally followed the pattern exhibited by the maximum Nacconol dosage.

The results of cationic Ceepryn additions are presented in Table IV. The first dosage of the lowest detergent concentration (10 p.p.m.) had no effect on nitrate production, whereas 100 p.p.m. Ceepryn caused an immediate decrease. The intermediate detergent concentrations displayed a stimulatory action upon the first addition and was followed by a reduction in nitrate production with subsequent Ceepryn additions. Nitrate formation was completely arrested within 2 days (3rd passage) for 50- and 100-p.p.m. Ceepryn dosages, within 3 days (5th passage) for 25 p.p.m., and within 4 days (7th passage) for 10-p.p.m. Ceepryn additions (Figure 8). No marked accumulation of NO_2–N was encountered. This indicates that the ammonia oxidizers were affected simultaneously with the nitrite oxidizers and possibly to a slightly lesser degree.

The ammonia content of the effluents

TABLE IV.—Effect of Ceepryn on Nitrification by Activated Sludge

Passage No.	Sewage NH_3–N Added (p.p.m.)	Control			Ceepryn												
					10 P.P.M.			25 P.P.M.			50 P.P.M.			100 P.P.M.		
		NH_3–N (p.p.m.)	NO_2–N (p.p.m.)	NO_3–N (p.p.m.)	NH_3–N (p.p.m.)	NO_2–N (p.p.m.)	NO_3–N (p.p.m.)	NH_3–N (p.p.m.)	NO_2–N (p.p.m.)	NO_3–N (p.p.m.)	NH_3–N (p.p.m.)	NO_2–N (p.p.m.)	NO_3–N (p.p.m.)	NH_3–N (p.p.m.)	NO_2–N (p.p.m.)	NO_3–N (p.p.m.)
1	7.00	0.05	0.020	6.00	0.10	0.080	5.60	0.25	0.050	9.20	5.00	0.050	7.50	10.00	0.170	1.80
3	14.00	4.25	0.045	18.70	3.00	0.095	17.50	18.75	0.065	4.20	21.20	0.007	0	21.20	0.050	0
5	18.75	4.25	0.030	17.50	5.00	0.020	6.00	20.00	0.005	0	20.00	0.005	0	21.20	0.010	0
7	17.50	0.10	0.025	15.00	14.00	0.005	0	14.00	0.005	0	13.00	0.010	0	12.00	0.005	0
9	32.50	13.00	0.045	27.50	42.50	0.020	0	42.50	0.020	0	42.50	0.020	0	32.50	0.020	0
11	13.00	5.00	0.020	13.75	14.00	0.010	0	15.00	0.010	0	14.50	0.005	0	14.50	0.005	0
13	13.00	0.05	0.015	15.00	11.00	0.025	0	12.00	0.020	0	13.00	0.020	0	12.00	0.020	0

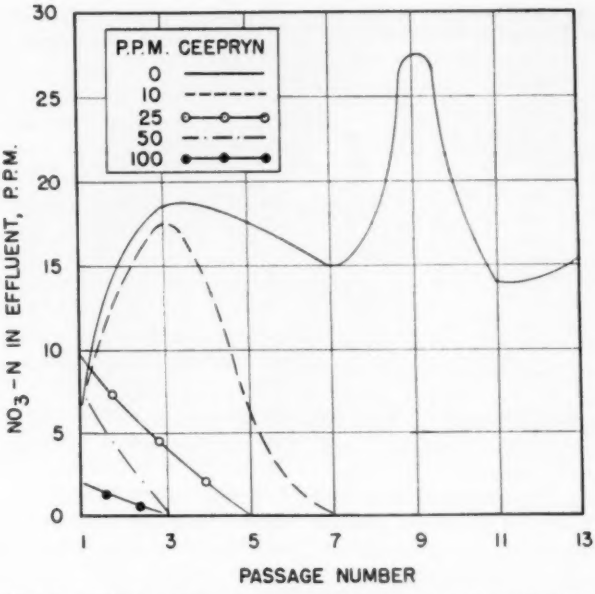


FIGURE 8.—Effect of Ceepryn on NO_3-N production by activated sludge.

increased immediately above the control level and exceeded the concentration present in the sewage added, but in the later stages of the experiment the ammonia content of the effluents returned to the level present in the sewage.

It follows that suppression of nitrite and nitrate production by Nacconol and Ceepryn additions results in accumulation of NH_3-N in the effluents. Increase in the NH_3-N content at the peak levels, above the concentration present in the sewage used, may be accounted for by the continued biological ammonification. Return of the NH_3-N content to that of the corresponding sewage indicates gradual displacement of the high ammonia-bearing liquid in sludge interstices concomitantly with inhibition of the ammonifying microorganisms.

The results obtained with repeated additions of 50 and 100 p.p.m. non-

TABLE V.—Effect of Tween 80 on Nitrification by Activated Sludge

Passage No.	Sewage NH_3-N Added (p.p.m.)	Control			Tween 80					
					50 P.P.M.			100 P.P.M.		
		NH_3-N (p.p.m.)	NO_2-N (p.p.m.)	NO_3-N (p.p.m.)	NH_3-N (p.p.m.)	NO_2-N (p.p.m.)	NO_3-N (p.p.m.)	NH_3-N (p.p.m.)	NO_2-N (p.p.m.)	NO_3-N (p.p.m.)
1	7.00	0.05	0.020	6.00	0.10	0.025	5.0	0.15	0.010	2.5
3	14.00	4.25	0.045	18.70	5.00	0.040	—	5.00	0.030	—
5	18.75	4.25	0.030	17.50	0.70	0.030	—	0.70	0.020	—
7	17.50	0.10	0.025	15.00	0.20	0.015	—	0.20	0.010	—
9	32.50	13.00	0.045	27.50	6.00	0.040	—	4.00	0.035	—
11	13.00	5.00	0.020	13.75	0.80	0.015	—	0.80	0.020	—
13	13.00	0.05	0.015	15.00	0.01	0.005	—	0.02	0.002	—

TABLE VI.—pH and Turbidity of Effluents from 13th Passage of Detergents

Detergent	Conc. (p.p.m.)	pH	Turbidity (p.p.m.)
Control	0	6.5	10
Nacconol NR	10	7.3	13
	25	8.1	42
	50	8.1	58
	100	8.2	80
Tween 80	50	6.5	12
	100	6.4	12
Ceepryn	10	8.1	52
	25	8.1	120
	50	8.1	286
	100	8.2	170

ionic Tween 80 depicted a pattern similar to that of the control (Table V). The NO_3–N values were unobtainable because of interference with the method employed. Qualitative observations demonstrated the presence of substantial NO_3–N content comparable to the amount yielded by the control. This may be corroborated by the fact that NH_3–N concentrations of the effluents were low; generally less than the corresponding control effluents, possibly indicating the utilization of additional nitrogen during the oxidation of the added decomposable nonionic agent.

The pH and turbidity values of the effluents from the 13th passage of detergents are given in Table VI. The control and Tween 80 effluents, in which active nitrification occurred, displayed a comparable slightly acidic reaction, whereas the effluents in which nitrification had been inhibited manifested a rise in pH. The turbidity values increased from 10 and 12 p.p.m. for the control, and Tween 80 effluents to 80 p.p.m. for the maximum Nacconol concentration. The turbidity of the Ceepryn effluents increased to 286 p.p.m. for 50 p.p.m. and to 170 p.p.m. with the highest Ceepryn dosage. The higher Ceepryn concentrations caused flocculation of a portion of the colloidal matter which was not determined. The increase in turbidity, in the case of Nacconol additions, indicates interference with the clarification ability of activated sludge, as well as deterioration of the biological floc; another factor, interaction with anionic com-

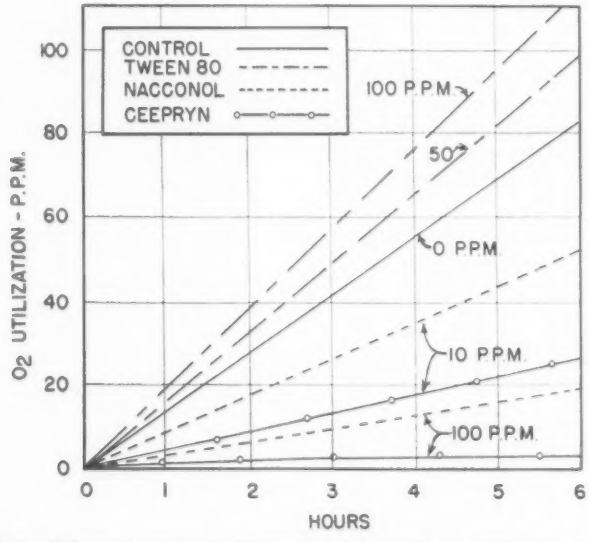
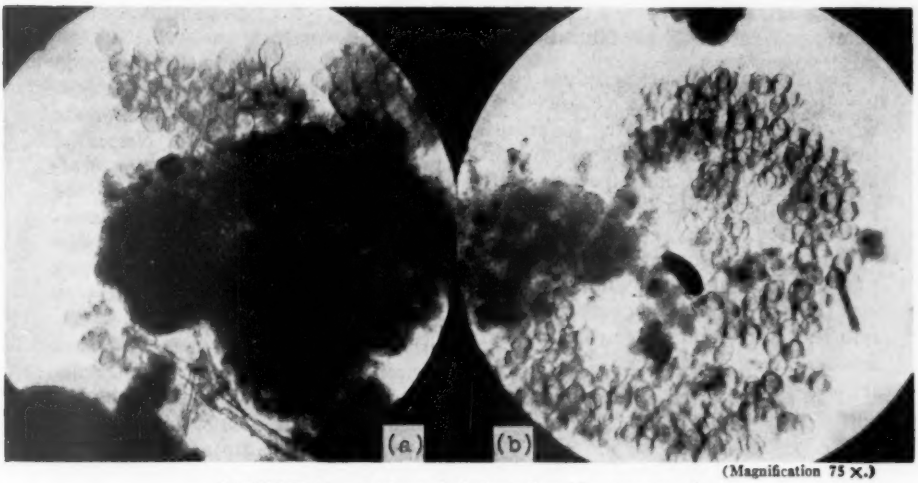


FIGURE 9.—Effect of repeated additions of detergents on oxidation of sewage by activated sludge.



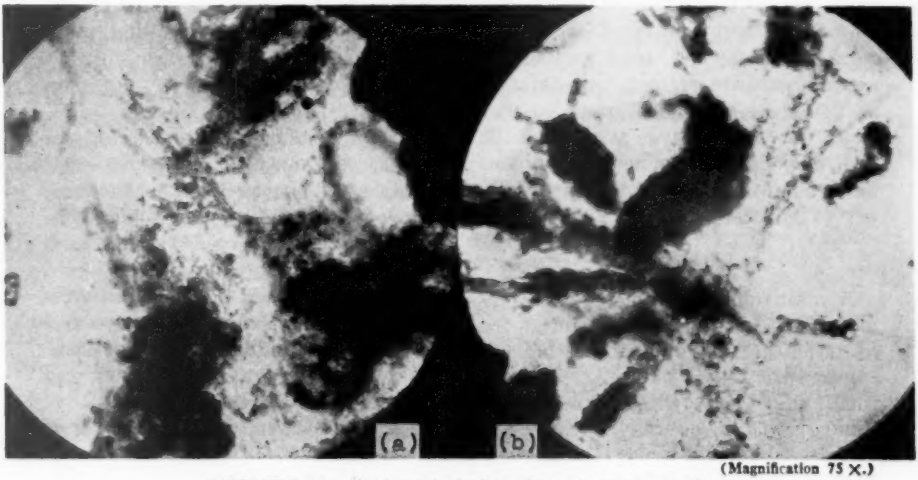
(Magnification 75 X.)

FIGURE 10.—Activated sludge after 13 passages of:
(a) Sewage (control).
(b) 100 p.p.m. Tween 80.

pounds in sewage, must also be included for the cationic Ceepryn.

The 6-hr. oxygen utilization values for detergent treated activated sludge with fresh sewage and detergent additions are shown in Figure 9. The greater oxygen uptake in the presence of nonionic Tween 80 demonstrates the oxidizability of this detergent. The sludges previously treated with increasing quantities of anionic Nacconol exhibited decreasing capacity for sewage oxidation. A similar effect with cationic Ceepryn is evident, but to a more marked degree.

Microscopic examination of the



(Magnification 75 X.)

FIGURE 11.—Activated sludge after 13 passages of:
(a) 100 p.p.m. Nacconol.
(b) 100 p.p.m. Ceepryn.

sludges after 13 passages of the various detergents revealed the following:

The Tween 80 treated sludges (Figure 10b) and the control (Figure 10a) were comparable, appearing flocculent, light brown, and containing abundant and active colonial and free-swimming protozoal forms with higher organisms interspersed.

The activated sludge treated with 10 p.p.m. Nacconol was similarly flocculent, but in general appeared to contain less active and fewer colonial and free-swimming protozoa. The sludge from 25-p.p.m. Nacconol additions was darker and more condensed in character, with only stalks of the colonial types remaining and no apparent free-swimming forms. The activated sludges treated with higher concentrations of Nacconol displayed high degree of condensation within the matrix. Cessation of activity was apparent. The residual stalks of the colonial protozoa and absence of free-swimming forms are depicted in Figure 11a.

All the Ceepryn treated sludges exhibited no protozoal activity. Disintegrating stalks of colonial protozoa were evident, but no free-swimming types were observable. The sludge masses were dark and condensed in character, the degree of condensation increasing with increasing concentration of detergent added. The sludge particles were not as large as those of the control and appeared to have spinous filaments protruding from their periphery (Figure 11b).

Discussion

A multitude of microorganisms, indigenous to sewage, are essential for initiation and maintenance of biological treatment processes. At the same time, they may create undesirable slime growth in sewers.

Compounds such as surface-active agents, appearing in increasing amounts in sewage, may affect these microorganisms and their activities, depending on the types and concentrations of agents present.

Anionic and nonionic detergents, in the low concentrations expected in sewage, could produce an over-all increase in slime growth in sewers. Normally, slime masses are received at the treatment plant because of sloughing or cleaning out of old growth in the sewers. In the future, more slime discharged at more frequent intervals can be expected, while greater quantities of growths remain in the sewers. Obviously, increased difficulties may be encountered with certain treatment devices. The possibility exists of higher quantities of detergents, contained in industrial wastes, limiting slime masses in sewers, but a detrimental effect on subsequent biological treatment processes may be imposed. The arrestment of slime growths by low concentrations of cationic detergents is also indicated; hence, their use for slime control in sewers and sewage treatment devices is a logical consideration.

The microorganisms active in the activated sludge matrix are not hindered by repeated additions of oxidizable, nonionic Tween 80. However, continuous dosages of the Nacconol and Ceepryn types retard the oxidizing capacity of these organisms and may cause a decrease in purification efficiency, necessitating longer aeration periods, without considering the additional problem of excess frothing in this process. As yet, it does not seem probable that the community of organisms constituting activated sludge can be acclimatized to such anionic and cationic detergents.

Interaction of anionic and cationic agents to form insoluble complexes diminishes the inhibitory effect of each detergent singly on biological oxidation. In other words, the probability of reaction betwen the detergent and the cell or cellular constituents of the microorganisms is lessened. A detergent which still possesses its particular ionic charge remains capable of react-

ing with substances of the cell. Thus, the concentration of the detergent in this state is more significant than total concentration of the agents present. In sewage, the ionic detergents are subjected to a host of oppositely charged compounds including other detergents, with which they may react, consequently limiting their interference with biological oxidation. Factors such as continuous flow process, wasting of sludge, concentrations, and variable discharge of detergents influence the extent of the effect on the activated sludge process.

Ammonification or the decomposition of organic nitrogenous compounds to ammonia by hydrolytic and oxidative mechanisms of numerous heterotrophic microorganisms in activated sludge antecedes the nitrification process. The subsequent oxidation of ammonia is performed in two stages by aerobic autotrophic bacteria present in the activated sludge mass, as follows:

$$2NH_3 + 3O_2 \rightarrow 2HNO_2 + 2H_2O + \text{Energy}$$

$$2HNO_2 + O_2 \rightarrow 2HNO_3 + \text{Energy}$$

Substances inhibiting the organisms capable of oxidizing nitrites to nitrates cause an accumulation of nitrites. Inhibition of ammonia oxidizers results in an increase in ammonia content of the effluent and, consequently, prevents the formation of nitrates.

Additions of nonionic Tween 80 exhibit no effect on the ammonification and nitrification processes. Repeated additions of anionic Nacconol first retard the activity of the nitrite oxidizers, yielding increase in nitrite concentration, then curb the activity of the ammonia oxidizers, and finally interfere with ammonification. Cationic Ceepryn affects the ammonia oxidizers to a lesser degree, but at the same time as the nitrite oxidizers. Further additions of this agent have a detrimental effect on the ammonifying organisms.

Under laboratory conditions, the detrimental action of Nacconol and Ceepryn is observed within a relatively short time. Suppression of the nitrite oxidizing organisms occurred within 48 hr. (3 passages) for all concentrations (10 to 100 p.p.m.) of Nacconol and Ceepryn, whereas complete inhibition of the nitrite oxidizers was evident in 5 days (9th passage) or less for all concentrations of both ionic agents, with exception of 10-p.p.m. Nacconol additions, which showed continued retardation through 7 days. In the main, the effects of cationic Ceepryn were more marked.

In general, the oxidative ability of the sludge organisms was diminished, the community of organisms and the character of the biological floc being impaired by repeated additions for a 1-week period of Nacconol and Ceepryn type detergents in concentrations of 10 to 100 p.p.m.

Since activated sludge is retained from, say, 2 to 7 days in the aeration tank, the extent of interference with the nitrification processes will vary with the sludge age and the concentration and type of detergents present in sewage.

Summary and Conclusions

Extensive laboratory experiments, conducted to determine the effect of three different types of detergents on slime growth and biological activity in activated sludge, show that:

1. Slime growths and biological treatment processes, established by autochthonous sewage microorganisms, are influenced in various ways by the presence of synthetic detergents in sewage.

2. Low concentrations of anionic (Nacconol NR) and nonionic (Tween 80) detergents stimulate slime growths, whereas definite retardation is caused by a cationic (Ceepryn) agent.

3. Repeated additions of Nacconol and Ceepryn cause a decrease in oxidizing, purifying, and nitrifying capacities of activated sludge, along with

a general deterioration of its physical and biological properties.

4. Oxidizable, nonionic Tween 80 induces no detrimental effect on activated sludge or its activities.

5. Interaction of anionic and cationic detergents tends to diminish the inhibitive action of these materials on oxidation by activated sludge organisms.

6. Nacconol and Ceepryn have a marked detrimental effect on the stalked and free-swimming protozoa present in activated sludge.

Reference

1. Manganelli, R., "Detergents and Sewage Treatment." THIS JOURNAL, **24**, 9, 1057 (Sept., 1952).

SEWER SERVICE CHARGE DEVELOPMENTS IN 1952

Adoption of service charges, particularly for sewer service, was a device widely used by municipalities during 1952 in their efforts to raise additional revenues, according to a report of the Municipal Finance Officers Association.

Almost all Minnesota cities and villages building new sewage disposal plants now use sewer service charges as a means of defraying at least a portion of the construction cost. Missouri cities, authorized by a 1951 legislative act to issue sewer revenue bonds and establish sewer rental charges, are increasingly turning to this device.

Increased use of sewer rentals is also apparent in California. Placerville now includes such a charge on its water bills. Residents of Alameda, Albany, Berkeley, Emeryville, and Piedmont now pay a sewer rental charge to the East Bay Municipal Utility District.

San Angelo, Tex., adopted a sewer service charge of $1 per month per residence. Acting under a 1951 legislative act, Morgantown, W. Va., imposed a sewer rental charge of 50 per cent of the water bill.

OPERATING EXPERIENCES WITH DETERGENTS AT WASHINGTON, D. C.*

By Ralph E. Fuhrman and John E. Rice

Superintendent and Chemist, respectively, District of Columbia Sewage Treatment Plant

The sensational increase in the use of synthetic detergents, coupled with a rising per capita use of all detergents, has given those concerned with waste treatment and receiving streams some new problems during the last decade. In this period, per capita use of all detergents has increased more than 10 per cent, the population of the United States has increased 13 per cent, and the production of "syndets" has increased from practically nothing to approximately half of all detergents being made. Although these facts appear to make innocent commercial news, the present and future effects of this large amount of such material discharged with the used water supply have a definite effect on the design and operation of sewage treatment plants.

The authors have been unable to obtain actual figures on the use of detergents of various types in the Washington, D. C. area. These data are not available because of their commercial value in competition between various brands. From a knowledge of the area's domestic habits, water hardness, and sewage characteristics, it appears that approximately one-half of the former soap use has been replaced by synthetics of one type or another.

The District of Columbia sewage treatment plant is similar to many other primary treatment plants. The treatment processes include grit removal, pre-aeration, and sedimentation. The sludge and scum removed are digested, elutriated, and dewatered on vacuum filters. Analyses indicate that the sewage is weaker than that usually found in a community of 1,000,000 persons. Because of the almost complete absence of wet industries, the sewage is considered completely domestic.

In addition to the regular treatment plant, there exist at the plant facilities for pumping settled sewage or plant effluent through tanks equipped for compressed air aeration and secondary settling. These tanks provide detention periods of 1 hr. in the aeration tank and 1.5 hr. in the secondary settling tank at a flow of 340,000 g.p.d. Return of sludge reduces the aeration period given. These arrangements were provided for aeration experiments by Guggenheim Brothers, Inc., and since the Guggenheim work was stopped late in 1949, the units have been left for use by the plant. These tanks have been useful in extending laboratory aeration studies to a large pilot-plant scale. This work has been of direct value, as high-rate activated sludge has been adopted as the best means of increasing the degree of treatment at the plant.

The high-rate activated sludge units to be constructed will provide 2-hr. aeration based on mixed liquor with 5 per cent sludge return for the expected 1980 maximum summer month flow of 290 m.g.d. and final sedimentation for 1.63 hr. at this flow. Present construction schedules call for the completion of the first half of the secondary treatment plant in 1956 and the second half in 1960. With these facilities, the degree of B.O.D. removal is expected to be increased to 70 or 75 per cent.

A primary treatment plant does not

* Presented at 25th Annual Meeting, Federation of Sewage and Industrial Wastes Assns.; New York, N. Y.; Oct. 6–9, 1952.

give the opportunity for observations on the effects of synthetic detergents nearly so much as plants employing regular or high-rate activated sludge or contact aeration. The frothing which has become associated with these secondary treatment processes is the most serious effect attributed to synthetic detergents in sewage treatment. In search for other effects, various observations have been made to evaluate effects of synthetic detergents at the plant.

Flett and Hoyt (1) have shown the increased use of detergents in the United States, and the increased proportion of synthetic detergents. Table I shows the sewage characteristics during early years of plant operation compared to the year ending June 30, 1952. It appears that there has been a marked change in the characteristics listed, with a noticeable decrease in B.O.D., but little change in suspended solids. The decrease in dissolved B.O.D. is marked.

Table II shows the relative per capita B.O.D. values for 12 years of plant operation. The values are not considered firm values of the per capita B.O.D. because the actual contributing population is difficult to determine.

There is a slight downward trend in the most recent years, which is attributed to the replacement of soap with its high B.O.D. by syndets of very little or no B.O.D. This effect may be approximated quantitatively. Washington sewage prior to World War II contained 25 to 40 p.p.m. of saponifiable fats, which accounted for 25 to 30 per cent of the incoming B.O.D. Reducing this by one-half for a 50 per cent substitution of synthetic detergents for soap could account for a drop in raw B.O.D. of 12 or 15 per cent. The authors believe this is not shown by these data because of increased load from ground garbage.

Figure 1 shows the annual variation of the B.O.D./S.S. ratio in the crude sewage and in the sludge and scum removed by the settling tanks. The removal curve was computed from the values for raw and settled sewage. The downward trend of the B.O.D./S.S. ratio during recent years with increased use of synthetics suggests that the new detergents are a likely factor.

In an attempt to measure the frothing properties of D. C. sewage, the experimental plant was operated in a manner expected to produce frothing. In normal operation the experimental aeration tanks had a small amount of froth at 8:00 each morning, but this disappeared regularly within 2 or 3 hr. From observations on the

TABLE I.—Sewage Characteristics at District of Columbia Sewage Treatment Plant

Item	1939–1943[1]		1952[1]	
	Raw	Eff.	Raw	Eff.
B.O.D. (p.p.m.)	172	114	119	84
Susp. Solids (p.p.m.)	177	89	170	80
Ratio B.O.D./S.S.	0.97	1.28	0.70	1.05
Soluble B.O.D. (%)	33	50	25	33
B.O.D. removal (%)	—	34	—	29

[1] Fiscal years.

TABLE II.—Per Capita Daily B.O.D. at District of Columbia Sewage Treatment Plant

Fiscal Year	5-Day B.O.D. (p.p.m.)	Av. Flow (m.g.d.)	Est. Population (1,000's)	B.O.D. per Capita (lb./day)
1941	171	108.4	940	0.164
1942	192	110.0	1,025	0.172
1943	171	121.7	1,120	0.155
1944*	154	129.5	1,135	0.146
1945*	139	144.1	1,120	0.149
1946*	136	150.2	1,140	0.149
1947*	145	147.6	1,100	0.162
1948*	139	151.2	1,140	0.154
1949	121	171.4	1,142	0.151
1950	132	160.1	1,140	0.154
1951	124	160.3	1,140	0.145
1952	119	172.7	1,140	0.150

* B.O.D. of these years adjusted from 16-hr. to 24-hr. sampling basis.

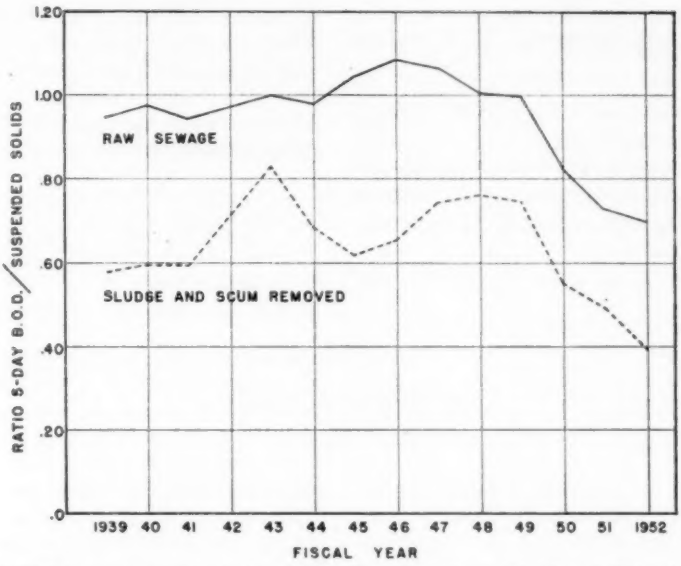


FIGURE 1.—Annual variation of B.O.D./S.S. ratio at District of Columbia sewage treatment plant.

experimental plant, factors observed as favoring the formation of froth were (a) weak sewage, which normally reaches the plant between 2:00 AM and 8:00 AM, with a resultant reduction in load on the secondary experimental unit; (b) rates of air application above 1.5 cu. ft. per gallon; (c) detention periods in the aeration tank greater than 2 hr.; and (d) concentration of suspended solids in the mixed liquor below 400 p.p.m. Although all of these factors are considered important, it is clear that they are not independent of each other. Little or no froth formed when the primary effluent was comparatively strong with an air application at the usual rate of approximately 0.5 cu. ft. per gallon, when aeration time was limited to about 1.5 hr., or when the mixed liquor was maintained at 500 p.p.m. or more of suspended solids.

When an air-lift was used to pump return sludge to the aeration tank, froth frequently formed in the discharge boxes after the solids had passed through and the lift was discharging liquid approaching the mixed liquor strength. The small amount of froth from this source and from the diffusers did not accumulate in the aeration tank during the operating day when the plant primary effluent was at or above average strength. The accumulation and dispersion of froth in the discharge boxes was observed to have a period similar to the discharge of sludge scrapers in the final settling tank. In these units this interval was 9 min. Normal flow through the tank caused the froth to pass over the outlet weir and disperse. Under these experimental conditions froth could be produced practically at will by allowing the air supply to continue with no sewage flow through the tank.

Summary and Conclusion

Operating experiences with synthetic detergents at the D.C. sewage treatment plant have not required any major operational changes. Changes in sewage characteristics during recent

years are believed to be caused partly by synthetic detergents. These changes include:

1. Reduction of per capita B.O.D. of the sewage.
2. Reduction of efficiency of the primary treatment units, on the basis of percentage removal of B.O.D. and suspended solids.
3. Little effect on the B.O.D. and suspended solids of the primary effluent.

It is believed that the reduction in load from the synthetic detergents is partly offset by added load on the system caused by ground garbage.

Reference

1. Flett, L., and Hoyt, L. F., "Detergent Compounds—Their Composition and Behavior." THIS JOURNAL, **25**, 3, 245 (Mar., 1953).

DISCUSSION

By Samuel A. Greeley

Consulting Engineer, Greeley and Hansen, Chicago, Ill.

There is much of interest in Mr. Fuhrman's paper. His Table I shows a lowering of the B.O.D. in the raw sewage at the District of Columbia plant from 172 to 119 p.p.m. There also was some decrease in the percentage of removal by sedimentation from 33.8 to 29.4 per cent. The unit quantity of B.O.D., in pounds per capita per 24 hr. (Table II), does not indicate much change, but whatever there is, is downward. These things make the selection of bases of design for the new District of Columbia works a difficult task, to which is added the difficulty of an expected but unknown increase in the use of household and restaurant garbage grinders. In studying the characteristics of sewage in other places, not much change has been found in the B.O.D. concentration since the advent of detergents. How then shall the bases and details of design of a new plant be determined?

First, a digression is in order to comment on froth control practice. Two procedures are now attracting attention—defrothing agents and sprays. Present rather limited experience indicates an efficient quantity for sprays to beat down froth of 15 to 20 g.p.m. per m.g.d. of sewage. The sprays may be operated continuously except during the weak sewage hours, or perhaps intermittently. The quantity of froth control spray water or effluent may also be stated in g.p.m. per linear foot of aeration tank, the units seeming to range from 0.25 to over 0.50 g.p.m. per foot of aeration tank.

There is indication that defrothing agents are being used at rates varying from 2.5 to 7.5 lb. per m.g.d. of sewage. The lower rate of application costs about 35¢ per m.g.d. for the agent alone. The agent may be introduced into the spray effluent or into the return sludge.

The possibility of split treatment should be noted. Under this procedure, a portion of the sewage would be given a higher degree of treatment, which would permit a relatively high quantity of suspended solids in the mixed liquor. Experience may indicate this to be a practicable way of controlling froth. A control chamber to accomplish this is included in the preliminary bases of design of the District of Columbia plant.

Obviously, there must eventually be had some knowledge of what conditions cause and influence froth formation and control. Among these, the characteristics of the sewage are important, as are also the kind of aeration and the suspended solids in the mixed liquor. At New York, Los

Angeles, and Philadelphia, all with low suspended solids in the aeration tanks, there has been considerable frothing. However, there has been some frothing at the Nassau County plant on Long Island with 2,000 p.p.m. of suspended solids in the mixed liquor.

Some sewages may contain froth reducing agents if such should be contributed by certain kinds of industry. Other influencing local conditions may be temperatures, sunlight, rains, and winds.

Mr. Fuhrman has stated the main bases of design of the additions for treatment by aeration at the District of Columbia plant, now under design and construction. The quantity expected for the maximum summer months is 290 m.g.d. and the displacement period based on mixed liquor with 5 per cent return sludge is 2.0 hr. Of course, much data and study underlie these bases. It is proposed to operate the aeration plant during the five summer months of years when the discharge of the Potomac River is low. It is desired to produce an effluent containing about 35 p.p.m. of B.O.D. The bases of design are intended to accomplish 75 per cent reduction of the B.O.D. in the raw sewage.

A few items from the bases of design as of the year 1980 are as follows:

1. Sewage quantities—

Annual average	240 m.g.d.
Summer average	266 m.g.d.
Max. summer mo.	290 m.g.d.

2. Population—1,500,000
3. B.O.D. in raw sewage—

Sewage	133 p.p.m.
Garbage	17 p.p.m.
Total	150 p.p.m.

4. B.O.D. in settled sewage applied to aeration tanks—

Sewage and garbage	100 p.p.m.
Reduction by sedimentation	28.5%

5. B.O.D. in effluent—

Desired or needed	37 p.p.m.
Expected	30 p.p.m.

6. Susp. solids in mixed liquor—300 to 600 p.p.m. (depending upon the temperature, with an average during the summer months of 400 p.p.m.)
7. Available quantity of air—0.50 cu. ft. per gal. during the maximum summer month.

It appears from the foregoing discussion that a considerable measure of operating flexibility for froth control is provided.

DISCUSSION

By Harvey E. Berg

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The information presented by Mr. Fuhrman, particularly that obtained in his essentially pilot-plant operation, is very interesting. No doubt when the data from many plants have been accumulated, tabulated, and studied, a great deal of helpful information will be available to sewage plant operators and design engineers. The researchers of the National Aluminate Corp. also are fortunate in having made available for their studies a small activated sludge plant treating only domestic sewage. This plant has a design flow of 0.015 m.g.d., a primary tank capacity of 1,500 gal., a mechanical aeration tank of 10,350 gal., a clarifier of 1,215-gal. capacity, and a digester of 1,550 cu. ft.

One of the chief obstacles in getting started with the investigation of the problems involved in sewage operation

because of detergent inclusion has been to ascertain the actual facts relating to the problem. This has necessitated spending considerable time on development of the problem itself before active work could be started on its solution.

The most talked of and publicized effect of synthetic detergents is the froth formation which is most noticeable in aeration tanks. Probably when all the facts are known and understood, this froth formation may only be a small factor in the over-all effect of these materials. It is well to point out that the term "synthetic detergent" as used in this discussion includes the complete formulation as it is used, consisting of builders and detergent assistants, as well as the active detergent itself. In this over-all picture the effect of each component part of the formulation has not been considered separately.

The effect of synthetic detergents in the primary tanks is probably that of dispersion and retarding of sludge settling. There is some difference of opinion among operators as to whether this is a real problem or a problem which is assumed to exist. About one-half of the operators with whom this problem was discussed claim that the synthetic detergent does not affect the primary tank operation; the remainder feel that it does. It is possible that the extent of the effect is relative and more noticeable in hard-water areas, where the soap precipitated by the hardness in the water acted as an aid to flocculation of sediment. With the advent of the synthetic detergent this aid was eliminated. In other areas, soap, which was not precipitated, itself acted as a dispersant so that any additional difficulty was not so noticeable as in the previously mentioned instance. Nevertheless, because of the inherent dispersive characteristics of the synthetic detergent, it can be assumed that they do present a problem in primary tank sludge sedimentation. Therefore, attempts are being made to develop a coagulant that will be effective for sludge in the presence of synthetic detergents. None of the usual chemicals and coagulation methods presently used seem to completely fill the requirements for this operation.

The four points mentioned by Mr. Fuhrman as affecting foaming in secondary tanks—namely, weak sewage, increase of air input, increase of detention, and reduction in suspended solids—may not be independent of each other as stated by Mr. Fuhrman. In the writer's opinion they are all related to the degree of aeration of the secondary sewage. So far as froth is concerned, it seldom if ever occurs in primary tanks. As a matter of fact, some operators believe that raw sewage will act as an antifoam, and it is understood that some are feeding raw sewage at various points in their aeration tank for this purpose. It is also understood that some operators are controlling foam by regulating the amount of air input to the secondary treatment tanks. This, of course, is stop-gap treatment, is not consistent with the best accepted practices, and may result in other difficulties more important than the nuisance caused by the presence of froth.

One of the interesting considerations found in the experimental work mentioned has been the distribution of bacteria in the various phases of the secondary tank. For example, it has been found that the bacteria counts in the foam phase are at least 20 times as high as the bacterial population in the liquid phase at the same relative point in the tank. Actually, according to the bacteriologist, this ratio is higher than reported, as the pin-point coliform colonies present on the plated foam phase were not taken into consideration, but merely recorded as "too numerous to count." It is not known what this means or what over-all effect it might have on operation, but it certainly is a point that should be considered in any investigational work which might be undertaken.

A great deal of the work in which the National Aluminate Corp. is inter-

ested deals with water clarification. At times the researchers are confronted with the flotation of solids which are normally easily settled when flocculated. In a number of instances this difficulty has been successfully overcome by the use of an antifoam, which liberates the air bubbles attached to the suspended material and which causes the suspended material to float in the water. The same condition may apply in the settling basin after the aeration tanks. This, of course, should be taken into consideration when evaluating the efficacy of an antifoam. One of the points of evaluation attempted is to determine the quantity and rate of settling of suspended solids. This is difficult because of the fluctuation that may occur. To date there is nothing more constructive to report than the opinion of an operator that the amount of activated sludge "seemed" to increase when the antifoam was in use.

Some complaints have been heard from operators of sewage plants to the effect that since the advent of synthetic detergents, plants utilizing the gas from the digesters have been having difficulty maintaining the same gas production as previously obtained. Whether this is due to the condition of the sludge (as, for example, density) or from other causes should certainly be determined. Otherwise, these plants will not be able to maintain a balanced condition in their operation. It has been suggested that the phosphate builders may be the prime contributors to this difficulty.

It is, of course, only reasonable to expect that when extra chemicals have to be used to overcome difficulties and increase efficiency, costs will increase. Manufacturers are well aware that treatment costs must be kept in economical balance and as low as possible consistent with good operation of the plant. If not, they certainly would not be able to sell chemicals to the operating plants.

The specific problem of some operators is frothing, which can be satisfactorily controlled. Proper application of a good commercial antifoam will cost approximately $0.50 to $1.00 per m.g. of sewage treated. When consideration is given to the other advantages to be expected through the use of an antifoam, this does not seem to be an exorbitant cost.

It seems to be fairly generally accepted that approximately 40 per cent of the box detergents have been composed of synthetic detergents. This may be quite conservative, if personal experiences are indicative of the general trend. It also seems that the time when a non-sudsing detergent formulation will be accepted by the housewife is a long way in the future. Suds apparently may not be essential to detergency, as antifoam compounds are being sold to formulators of industrial cleaners who do not want their products to suds when used. However, to a housewife suds represents a measuring stick which she can use to satisfy herself that she is using sufficient detergent. As an example of this, not long ago the writer put a drop of one of his company's antifoam formulations in his wife's washing machine without her knowledge. She proceeded in the usual manner, and had put into the machine practically a box of detergent before she complained about the poor quality of the particular product and received an explanation of what had been done. Confidentially, the writer will never try that again. As a result of this attitude on the part of the housewife steps should be taken in the sewage plants to handle the problems the syndets present.

In conclusion, control of froth caused by synthetic detergents in sewage plant operations is one of the easier industrial foam control problems undertaken by the writer's company. A sample of detergent whose foaming characteristics could not be overcome and controlled by one of the antifoam formulations has yet to be received.

A SINGLE DILUTION TECHNIQUE FOR B.O.D. STUDIES *

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In some B.O.D. research investigations it is necessary to determine the B.O.D. of a substrate at various time intervals to determine such factors and influences on biological oxidation as (a) oxidation rates, (b) nitrification, (c) temperature, (d) nitrogen and mineral requirements, and (e) toxicity.

The standard B.O.D. bottle dilution method most commonly employed for such investigations presents several inherent difficulties to long-time B.O.D. studies, as follows:

1. A large number of individual B.O.D. bottles are required for a single test.
2. Several different B.O.D. dilutions are necessary.
3. Separate bottles must be used for other determinations, such as ammonia, nitrites, nitrates, and bacteria.

In the standard B.O.D. test, using individual bottles, it is assumed that the course of biological oxidation is the same in each bottle no matter what the dilution is. This assumption may lead to rather serious errors, because both nitrification and biological oxidation rates are apparently affected by the concentration of organic material in the B.O.D. substrate, as shown by Ruchhoft *et al.* (1). In long-time B.O.D. studies the standard B.O.D. technique is not sufficiently accurate to determine the small differences in B.O.D. after carbonaceous oxidation begins to taper off, say after 5 days. This often causes reversals in the B.O.D. curve and introduces problems in the interpretation of the results.

One method of overcoming these problems, used by many research workers, is to set up a series of bottles with the same dilution and then pool, reaerate, and redistribute the sample whenever necessary to prevent total oxygen depletion. Another B.O.D. dilution technique used to study the oxidation of stream water is described by Kittrell and Kochtitsky (2). "A large volume of each sample was incubated in an unstoppered bottle, from which B.O.D. bottles were filled for initial and final D.O. determinations. The final D.O. was determined after a limited period of incubation that would not cause total oxygen depletion. When the final D.O. was determined, another set of B.O.D. bottles was filled from the large bottle, which had been stored unstoppered in the incubator to permit continuing aerobic action. The process was repeated as necessary until the desired term of incubation was completed. For the long-term B.O.D. several B.O.D. bottles were incubated each time it was necessary to refill from the large bottle, to permit a final D.O. determination each day."

Jug Dilution Technique

In the "jug dilution technique" for B.O.D. studies, two 1-gal. jugs are used for each test, instead of a large number of B.O.D. bottles. Each jug is filled with an appropriate mixture of sample and dilution water. One jug is kept full and stoppered to exclude air. Samples are siphoned from this bottle for dissolved oxygen and other analyses. The volume of sample taken from the first jug is replaced from the second and the incubation is continued until

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the next sampling period. Thus, the sample volume of the second jug decreases as the B.O.D. test continues.

When the dissolved oxygen nears depletion, the sample jug is emptied into a large beaker or cylinder and aerated to replenish the oxygen. The jug is then refilled, a new sample taken for dissolved oxygen and the test continued. During the first few days dissolved oxygen is rapidly depleted, so the second supply jug should also be reaerated; after dissolved oxygen utilization tapers off, the second jug, which is not full, will receive enough reaeration from the air space above the liquid to make mechanical reaeration unnecessary.

All samples are taken from the closed jug and the sample volume is replaced from the second supply jug. It is necessary, therefore, that the ratio of the sample volume to the jug volume be small to minimize errors in dissolved oxygen concentration, due to differences in D.O. concentration between the sample jug and the supply jug. Dissolved oxygen samples are taken by siphoning the sample into 60-ml. glass-stoppered bottles. The dissolved oxygen is determined by the standard azide modification of the Winkler method (3) with the following modifications:

1. 0.2 ml. of each of the reagents is used instead of 1.0 ml., thus maintaining the same reagent concentration.

2. 50 ml. of sample is titrated with thiosulfate instead of 200 ml.

3. 0.00625N instead of 0.025N sodium thiosulfate is used for titration. Since the thiosulfate concentration is one-quarter and the sample volume one-quarter, the titration in ml. can be read directly as p.p.m. dissolved oxygen.

To minimize errors and standardize the procedure, a few simple techniques were developed for handling the jugs and making dissolved oxygen determinations:

1. The siphon is made from small glass tubing (2 to 3 mm. inside diameter) and connecting rubber tubing. The glass tube is bent about 135° at the top to form a hook, which will allow the tube to extend to a depth of 1 in. from the bottom. At the top the hook is about 1 in. long, and a piece of rubber tubing 6 in. longer than the bottle depth is attached to complete the siphon.

2. Before the sample is taken, the jug contents are stirred with the glass siphon rod. From 10 to 15 quick circular motions are usually sufficient. Since the jug is completely full and little surface is exposed, the amount of reaeration by stirring is insignificant.

3. The siphon rod is dropped to maximum depth so that the hook rests on the lip of the jug and the rubber tube is inserted in the D.O. sample bottle. The siphon is started by pinching the rubber tubing at the top and sliding the fingers down the tube. This pulls the liquid over the lip of the bottle and starts the siphon. When the D.O. sample bottle is filled, the siphon contents are emptied back into the jug.

4. At this point samples can be taken for bacteria counts, nitrites, nitrates, ammonia, or any other analyses desired.

5. If the contents do not need reaeration, the sample jug is filled to the top from the second supply jug, care being exercised in pouring, and a rubber stopper is inserted. To prevent an air bubble from forming under the stopper, a piece of wire (a straightened-out paper clip) is placed in the neck of the jug while the stopper is shoved into place. The small opening around the wire allows water displaced by the stopper to flow out, together with any trapped air. After the stopper is in place, the wire is pulled out and the stopper is securely held against removal by vacuum action. The inserting wire device is easier to use if one

end is wound around a nail, which serves as a handle.

6. If reaeration is required, the contents of the sample jug and, if necessary, both jugs, are emptied into separate vessels and reaerated by diffused air. With a diffuser only 4 to 5 min. of aeration are required; if air is bubbled from an open tube, 10 min. may be necessary. When no facilities for diffused aeration are available, the contents can be aerated by pouring several times between two vessels.

7. The dissolved oxygen determination requires the reagent modifications noted previously and also needs a slight change in titration technique to obtain accurate results. At the end of the titration, the blue starch-iodine color reappears in a few seconds, because the thiosulfate used is weak. Titration end-point errors can be minimized by adjusting the buret to a steady dropping rate after starch indicator is added and continuing at this rate until the color disappears. When the color disappears, the buret is shut off and no further thiosulfate is used even though the color returns. This technique is no different from standard iodine titration technique. The use of weaker thiosulfate requires that extra care be taken to prevent color return interference.

Accuracy of D.O. Determination Using 50-Ml. Samples

The accuracy of the small sample D.O. technique was determined in a series of four tests using 10 replicate samples taken for each test. The tests were made at different D.O. levels by four different persons. The following standard deviations were obtained:

Av. D.O. Level (p.p.m.)	Stand. Dev. (p.p.m. D.O.)
9.15	0.085
7.94	0.049
7.75	0.050
4.60	0.090
Av.	0.069

There is no apparent relationship between standard deviation and D.O. level, and differences in accuracy may be due to the technique of the individual analyst. The average standard deviation is about 0.07 p.p.m. D.O., which is the same as that found by the Federation Committee on Standard Methods. It can be concluded that with good technique the D.O. determination on 50-ml. samples is as accurate as with standard 200-ml. samples.

Other theoretically possible sources of error in the jug technique are reaeration during the transfer of samples for dissolved oxygen and dissolved oxygen increases in the sample jug because the second refill jug contains more dissolved oxygen than the sample jug. This source of error was investigated by making 20 consecutive transfers between two 1-gal. jugs containing waters with different dissolved oxygen concentrations. The transfers were made in exactly the same manner as the described jug procedure, including stirring. The sample jug had an initial D.O. of 4.3 p.p.m. and the supply jug 6.6 p.p.m. This D.O. differential is approximately the average D.O. differential observed in actual tests. During 20 transfers, the D.O. concentration in the sample jug gradually increased to 4.9 p.p.m., an increase of 0.6 p.p.m. D.O. The expected increase from the D.O. differential alone was 0.7 p.p.m., assuming 65 ml. of water was transferred each time.

From the results of this experiment it was concluded that no measurable amount of oxygen is added by reaeration during the transfer and that on the average the dissolved oxygen error is about 0.03 p.p.m. per transfer. For a B.O.D. experiment this would cause an error in the B.O.D. of about − 3 per cent. Since the error is distributed throughout the entire curve, the shape of the curve is not affected by neglecting the normal transfer error. If for any reason it is deemed necessary to reduce this error,

TABLE I.—Comparison of B.O.D. Results Obtained by Bottle and Jug Dilution Methods[1]

Jug Dilution Method[2]				Bottle Dilution Method[3]			
Time (days)	Av. B.O.D. (p.p.m.)	Stand. Dev. (p.p.m.)	Coef. of Var. (%)	Time (days)	Av. B.O.D. (p.p.m.)	Stand. Dev. (p.p.m.)	Coef. of Var. (%)
0.41	107.6	2.89	2.69	—	—	—	—
0.96	168.0	2.12	1.26	—	—	—	—
1.98	220.5	8.08	3.67	1.92	211.0	4.35	2.06
4.06	284.2	6.50	2.28	4.00	278.0	8.33	3.00
4.98	304.5	7.02	2.30	—	—	—	—
5.98	318.0	7.94	2.49	5.92	294	9.06	3.07
7.04	326.2	6.50	2.00	—	—	—	—
7.98	332.8	8.50	2.55	7.90	321	3.13	0.98
Av. to 7.96 days			2.40	Av. to 7.90 days			2.28
10.0	345.0	10.3	3.00	9.92	336[4]		
12.0	371.2	11.1	2.99	11.96	368[4]		
19.0	459.0	22.2	4.83	18.96	446[4]		
Av. to 19.0 days			2.73				

[1] Rutgers Housing Development raw sewage.
[2] Sewage dilution 1:30; four replicate samples.
[3] Sewage dilution 1:50; five replicate 300-ml. bottles for each observation period.
[4] Remaining 300-ml. bottles pooled, reaerated, and redistributed; two replicate bottles used for each observation period.

either approximate corrections can be made or the supply jug can be allowed to have a lower D.O. content by eliminating or reducing its reaeration.

Accuracy of Jug Dilution Technique

An experiment was made to determine the accuracy of the jug dilution technique and to compare it with the standard bottle dilution method. Raw sewage from the Rutgers Housing Development sewage treatment plant was used for the experiment. The sample obtained was wash-day sewage with a high laundry waste concentration. Four replicate samples were used for the jug method with a 1:30 sewage dilution, and a series of 300-ml. B.O.D. bottles were set up for the standard dilution method with a 1:50 dilution. Standard dilution water was used for both methods, and the mixtures were made in large bottles and siphoned into the jugs and B.O.D. bottles. For the bottle dilution method sufficient B.O.D. bottles were used so that the B.O.D. could be determined every second day with 5 replicate samples up to 8 days and with 2 reaerated replicate samples up to 19 days.

The average results, together with the standard deviation and the coefficient of variation (C_v = per cent standard deviation) for each observation period, are given in Table I and plotted in Figure 1. At the end of 19 days nitrites and nitrates were measured in both jugs and bottles and the observed B.O.D. values were corrected for nitrification. The carbonaceous B.O.D. curves for both B.O.D. methods are also shown in Figure 1.

Table II gives the computed k and L values for the two curves for various observation periods. The k and L values were computed by the "simplified method" (4) using uniform one-day intervals and B.O.D. values interpolated from the curves of Figure 1.

Analysis of the data shows that the bottle dilution and jug dilution methods give essentially the same B.O.D. results. However, over the entire curve the B.O.D. by the bottle dilution method is always slightly less than by

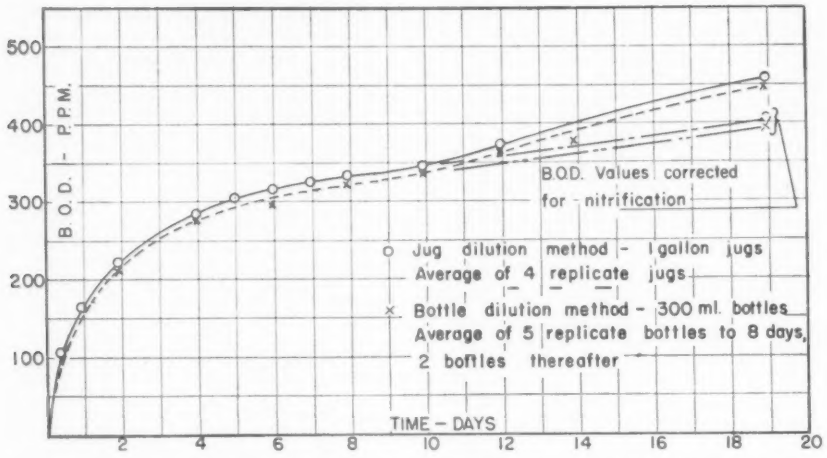

FIGURE 1.—Comparison of B.O.D. curves determined by bottle and jug dilution methods.

the jug method. The average difference is 3.3 per cent, with a range from 0.6 to 7.5 per cent. The difference is small, but since it is greater than the standard deviation and always in the same direction it is probably significant. The difference cannot be attributed to reaeration of the jug dilution samples, because the reaeration error tends to make the jug dilution B.O.D. lower. The observed B.O.D. difference between the two methods may be the result of other sources of error, such as:

1. Errors in the original dilutions.
2. Better oxidation in the jugs because of frequent mixing of the contents allowing better distribution of biological growths.
3. Increased B.O.D. contributed by the rubber stopper used in the jugs.
4. Errors in the relative strength of the thiosulfate used to titrate D.O. samples.

Of the errors suggested, the second could possibly cause the greatest difference. The two B.O.D. curves are very close and the differences observed are more likely to be caused by the mixing and redistribution of the biological growths.

TABLE II.—Comparison of *k* and *L* Values of B.O.D. Curves[1] Obtained by Bottle and Jug Dilution Methods[2]

Time Interval	Jug Dilution Method		Bottle Dilution Method	
(days)	*k*	*L*	*k*	*L*
3	0.40	276	0.38	267
5	0.32	302	0.31	294
7	0.29	315	0.28	307
10	0.24	335	0.23	325
14	0.20	353	0.19	346

[1] From Figure 1.
[2] Rutgers Housing Development raw sewage.

Advantages of Single Dilution Method

For the laboratory investigations, only two jugs would be required for a B.O.D. test over a period of days. In an experiment using the jug dilution technique it was possible to test 7 different sewages, making 14 different observations over a period of 18 days, with only 14 1-gal. jugs. If the same tests were made by the bottle dilution methods, approximately 300 B.O.D. bottles would be required.

The jug dilution technique has several advantages for many B.O.D. studies:

1. B.O.D. measurements are all made from the same bottle and the same sewage dilution. Differences in biological activity between several bottles do not affect B.O.D. results. This is particularly important when studying nitrification, bacterial numbers, and other phenomena related to oxygen utilization.

2. Samples for other determinations can be taken from the same bottle used for D.O. measurements.

3. The B.O.D. curves obtained are very smooth; B.O.D. always increases with time, thus simplifying analysis and interpretation of the data.

4. Errors made in one observation are minimized because the same sample is analyzed the next time. All observations are thus interrelated, and any deviation from a smooth curve indicates a probable error in observation.

5. Incubator shelf space required is small because only two jugs are used for each test.

Summary and Conclusions

A single dilution method for B.O.D. studies has been presented. The method consists of filling two 1-gal. jugs with the diluted mixture to be studied. The first jug is kept completely full and stoppered. Samples for dissolved oxygen measurements and any other desired analyses are siphoned from the first jug and replaced from the second jug after sampling so that the first jug is kept completely full and reaeration is prevented. When the dissolved oxygen content of the jugs is near depletion, the contents are reaerated and the process is continued. The advantages of the method are:

1. All B.O.D. measurements are made on one diluted sample.

2. Additional portions can be taken from the same diluted sample for other tests.

3. Smoother, more easily analyzed B.O.D. curves are obtained than with the standard bottle dilution method.

4. Less incubator space is required, because long-range B.O.D. studies can be made with only two 1-gal. jugs instead of a large number of individual B.O.D. bottles.

Acknowledgment

Portions of this paper were reported in a thesis submitted by the senior author to the Graduate School of Engineering, New York University.

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SEWAGE TREATMENT AND THE VIRUS OF POLIOMYELITIS

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The year 1952 saw the highest number of poliomyelitis cases on record (1). This review presents information relative to poliomyelitis and the sewage treatment process. As a guide to those individuals responsible for sewage treatment plant operation and design, emphasis is placed on critical analysis of available data.

Subsequent to the isolation of the poliomyelitis virus from the stools of infected patients, Paul and Trask (2) reported in 1942 the isolation of the virus from sewage. Their findings included the information that (a) the virus is present in sewage only when high case incidence exists and (b) the presence of the virus could at that time be detected downstream from treatment plant outfalls. Confirmation of the presence of poliomyelitis virus in sewage exists as a result of work in Stockholm (3), which demonstrated that monkeys inoculated with sewage evidenced the typical paralytic infection.

That the activated sludge process reduces virus concentration was reported in 1943 by Carlson, Ridenour, and McKhann (4). Their results disclosed that activated sludge liquor containing 1,100 p.p.m. suspended solids, aerated for 6 hr., largely removed the virus from the supernatant liquor. They indicated that "heavier concentrations of sludge with longer aeration periods largely eliminate infectivity" for mice injected intracerebrally. Carlson and McKhann (5) demonstrated the presence of an "antiviral substance" in activated sludge.

Epidemiology

Research has been conducted by Langmuir to establish the mode of transmission of the disease (6). Suspicion has been cast toward milk, water, sewage, fruit, vegetables, and insects at various times and by numerous individuals. Maxcy (7)(8) considers water supplies unlikely agents in the transmission of poliomyelitis. He points out that the personal contact theory may have application, stating "This concept is adequate to explain all of the known observations on the epidemiological distribution and characteristics of the disease." He does not disregard other means of transmission as being contributory, however. Nevertheless, he emphasizes that the failure of poliomyelitis to spread rampant, as did typhoid fever, practically eliminates it as a waterborne disease.

The fact remains, however, that suppression of poliomyelitis has not yet occurred. There is one pertinent factor on which virologists and epidemiologists agree—the consistency with which poliomyelitis seems to avoid falling into patterns normal to other transmissible diseases. Clinical manifestations of the disease vary from the usually unrecognized carrier to the bed-ridden paralytic. Aborted poliomyelitis cases occur in far greater numbers than the total number of paralytic cases reported (2).

Chlorine and Poliomyelitis

Investigations have been carried out to determine what effect, if any, con-

ventional chlorination procedures have on the virus of poliomyelitis. Kempf and Soule (9) in 1940 studied the effect of residual chlorine present in city water on a suspension of the virus. Inactivation of the virus failed to occur in water containing concentrations of 0.5 p.p.m. residual chlorine with 1.5 hr. contact. The probability exists that the residual chlorine existed as combined chlorine, since the work of Ridenour and Ingols (10) and of Lensen and his co-workers (11) demonstrates conclusively that free chlorine residuals as low as 0.1 p.p.m. with 30-min. contact effectively inactivate the virus.

It should be noted that these experiments were carried out with water. The presence of great quantities of organic matter in sewage and sewage plant effluent would render the establishment of free residual chlorine difficult indeed. The work of Lensen and associates (12) led them to believe "that the virucidal action of mixed residuals can be attributed entirely to the free chlorine only in case of such very low (less than 0.3 p.p.m.) residual chloramine values. In the presence of higher chloramine values the possibility of a combined action of free chlorine and chloramine should not be excluded." Their investigations disclosed that a free chlorine residual as low as 0.05 p.p.m. plus 0.45 p.p.m. chloramine at pH 6.85 to 7.4 effectively inactivated the virus after 10-min. contact. Significantly, they showed decreasing effectiveness of the free chlorine residual at a higher pH range (pH 8.95 to 9.25), the virus remaining active after 1-hr. contact.

Discussion

The inactivation of poliomyelitis virus in sewage plant effluent really involves two questions—one, of possibility; the other, of necessity.

It is very likely that inactivation of the virus in sewage could be accomplished. The control of certain factors, such as contact time and the maintenance of appropriate chlorine residuals, would be essential.

The need for inactivation of the poliomyelitis virus in sewage plant effluent is doubtful. It is submitted that, until specialists in virology and epidemiology can specifically point to poliomyelitis as a waterborne disease, sewage treatment plant operators should concern themselves with improvements in normal plant operation. That disinfection procedures can be improved has been reported by Pierce (13), whose work involving two-stage chlorination definitely shows the procedure to have promise where rigid coliform density control is required. The growing programs of pollution abatement, narrowing the acceptable limits of plant effluent as they do, give added emphasis to the necessity of improved disinfection procedures.

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1952 FOURTH QUARTER CONSTRUCTION APPROVALS

Approval of 463 water and sewage construction projects with a total value of $124,994,000 in the fourth quarter of 1952 was recently announced by the Water Resources Division, National Production Authority. All of the projects were granted construction permits and received allotments of controlled materials.

Of the total, 160 projects were for sewage works valued at $82,529,000, including estimated costs of all materials, labor, and engineering. Authorized sewage approvals declined from 253 in the third quarter, 308 in the second quarter, and 597 in the first quarter.

Controlled materials allotted by the Water Resources Division in the fourth quarter of 1952 totaled 123,635 tons of steel, 2,177,279 lb. of copper, and 119,818 lb. of aluminum.

New Jersey headed the fourth quarter construction approvals with the greatest dollar value ($17,011,440), although California had the greatest number of projects approved. The Pacific state's 65 approved jobs had an estimated aggregate cost of $11,670,000, whereas New Jersey had a total of only 7 projects authorized. Texas ranked second in dollar value, with $15,051,600 for 45 projects.

COMPUTATIONS OF B.O.D. FOR SEEDED SAMPLES OF HIGH DILUTION

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It is a well-known fact that, in the determination of the biochemical oxygen demand, the use of seeded dilution water having an appreciable B.O.D. of its own results in increasing B.O.D. values with decreasing concentration of waste. Whipple (1) said:

> When the oxygen demands of different concentrations are used to calculate the demand of the undiluted sample a series of different values often results. Usually the highest concentrations give the lowest values. This seeming inconsistency was investigated by Theriault and Hommon, who showed that the results obtained by incubating different concentrations could be harmonized if the concentrations were increased by a constant. The error was ascribed to a greater oxygen demand of the diluting water when incubated with waste or sewage than when incubated as a blank. The procedure that was proposed to allow for this was the use of diluting water that has been stored until its oxygen demand is less than 0.6 p.p.m. If such water is not used the results from various concentrations may be corrected by the differential method that cancels out the error common to all concentrations. Each concentration is subtracted from the higher concentrations to obtain a corrected concentration factor, and each depletion, without allowance for a water blank depletion, is subtracted from the higher depletions to obtain corrected values. When the oxygen demand of the sample is calculated from these results all concentrations will be in close agreement, provided the tests have been carried out accurately.

From the paper by Theriault and Hommon (2), referred to by Whipple, the following may be quoted:

> It is possible, however, that the oxygen demand of the diluting water is not the same by itself (in the blanks) as in the dilutions. A plausible explanation of this lies in the fact that the organic matter in the diluting water is already highly oxidized and is subjected to the action of but small numbers of attenuated bacteria; in the dilutions, however, this organic matter is subjected to the action of a greater variety of less attenuated bacteria. If this be the true explanation, the use of the diluting water having no oxygen demand would eliminate errors of this sort. This has been found to be the case and is the basis of the method at present used.

The fact that an incorrect, too low value of the B.O.D. of the blank will result in increasing values of the B.O.D. of the waste with decreasing concentrations can readily be demonstrated. Assume a certain waste having an actual B.O.D. of 600 p.p.m. and a diluting water which, in connection with the waste, has a B.O.D. of 0.8 p.p.m. Assume further that three different concentrations have been used—namely, 1:100, 1:200, and 1:400 (that is, 0.01, 0.005, and 0.0025)—and that the B.O.D. of the diluting water as a blank has been determined as 0.4 p.p.m. The resulting depletions of the three samples

TABLE I.—Theoretical Depletions for B.O.D. Determinations of Various Concentrations and the Calculated B.O.D. of a Waste Having an Actual Value of 600 P.P.M., When the B.O.D. of the Diluting Water, Actually Being 0.8 P.P.M., Has Been Determined To Be 0.4 P.P.M. As a Blank

Concentration of Sample (p.p.m.)	Dilution Factor	Theoretical Depletions (p.p.m.)	Calculated B.O.D of Waste (p.p.m.)
0.01	100	$0.8+0.01 \times 600 = 6.8$	$6.4 \times 100 = 640$
0.005	200	$0.8+0.005 \times 600 = 3.8$	$3.4 \times 200 = 680$
0.0025	400	$0.8+0.0025 \times 600 = 2.3$	$1.9 \times 400 = 760$

are shown in Table I, Column 3. The depletions, when corrected for the B.O.D. of the blank, will be 0.4 p.p.m. less. Calculations of the B.O.D. of the waste will result in values according to Column 4, Table I, instead of the actual value of 600 p.p.m.

In all three concentrations, the inaccuracy of the values obtained is caused by the constant error of using 0.4 p.p.m. instead of the correct value of 0.8 p.p.m. for the blank. Concerning this, Theriault and Hommon (2) state:

> It is evident that any constant common to each concentration would cancel out if the concentrations were subtracted from each other. . . . In this manner any constant error would cancel out. In practice this method is quite cumbersome, since three concentrations must be incubated to derive two independent values. Moreover, the depletions must be such that the values obtained by their subtraction are quite large or else the percentage error is great.

Applied to the case chosen in Table I, this procedure would mean that two independent pairs of values are obtained by subtracting the corresponding depletions and concentrations. Subtracting No. 2 from No. 1, the depletion is $6.8 - 3.8 = 3.0$ p.p.m. and the concentration is $0.010 - 0.005 = 0.005$ (that is, 1:200). Similarly, combining No. 2 and No. 3 gives $3.8 - 2.3 = 1.5$ and $0.0050 - 0.0025 = 0.0025$ (1:400). The calculated B.O.D. of the waste becomes $200 \times 3.0 = 600$ p.p.m., or $400 \times 1.5 = 600$ p.p.m., which is the correct value for both combinations.

Suggested Procedure

The error resulting from the conventional method of calculating the B.O.D. of a waste increases with increasing B.O.D. of the blank and with increasing dilution of the sample. To eliminate this error as far as possible, it is generally recommended (3) that a diluting water with a 5-day B.O.D. of not more than 0.2 p.p.m. be used. Occasionally, however, samples must be seeded and low concentrations must be used. Under such circumstances any direct determination of the B.O.D. of the blank should be avoided in order not to introduce a systematic error in the determinations. If the oxygen demand of the diluting water is lower when incubated alone as a blank than in the presence of the waste, why not actually determine it under these latter conditions? Moreover, the B.O.D. of the blank will rarely exceed a value of 1 p.p.m. For an ordinary B.O.D. determination, a depletion of 1 p.p.m. is so small that, according to "Standard Methods" (3), the result should be considered unreliable. It does not seem quite reasonable to use such an unreliable value for the blank in computing the B.O.D. of the sample.

As a matter of fact, the preparation and B.O.D. determination of a blank are unnecessary provided that at least two suitable determinations with different concentrations of the waste in question have been incubated. In that case, the following system of equations may be obtained, through which the B.O.D. of the waste, as well as that of the diluting water, may be computed.

$$L_w = n_1(D_1 - L_b) \qquad (1)$$

$$L_w = n_2(D_2 - L_b) \qquad (2)$$

where

L_w = the B.O.D. of the waste;
L_b = the B.O.D. of the diluting water;
D_1 and D_2 = determined oxygen depletions; and
n_1 and n_2 = corresponding dilution factors (that is, the reciprocals of the concentrations of the samples; see Table I).

Solving L_w and L_b from Eqs. 1 and 2, gives

$$L_w = \frac{n_2 n_1 (D_1 - D_2)}{n_2 - n_1} \qquad (3)$$

$$L_b = \frac{n_2 D_2 - n_1 D_1}{n_2 - n_1} \qquad (4)$$

Applying the values for the first two concentrations in Table I to Eqs. 1 and

2, gives

$$L_w = 100\ (6.8 - L_b) \qquad (5)$$

$$L_w = 200\ (3.8 - L_b) \qquad (6)$$

hence $L_w = 600$ p.p.m. and $L_b = 0.8$ p.p.m.

In cases where seeding is required and the concentration of waste is low, the B.O.D. of a sample may thus be easily and accurately determined by using two or more different dilutions which give suitable depletions. The incubation of the blank may be eliminated. The B.O.D. of the waste is then calculated by Eq. 3, and if the B.O.D. of the diluting water is wanted it may be calculated by Eq. 4. When more than two dilutions of suitable depletions are available, the system of equations will be over-determined. If its solution is carried through with due adjustment of all available values, this will lend further accuracy to the resulting B.O.D. The procedure could be applied in the same way to other diluting waters of insufficient stability, such as stream water.

Illustrative Example

The suggested procedure may be further illustrated by the example in Table II, selected from the determination of the immediate and 5-day B.O.D. values of an industrial waste.

The value of the dissolved oxygen of the dilution water being 7.5 p.p.m., the immediate oxygen demand of the waste is calculated as 50 p.p.m. A computation of the 5-day B.O.D. of the waste in the conventional way, using the B.O.D. of the blank (0.3 p.p.m.), gives for the different concentrations the values of 250, 280, 300, and 400 p.p.m. However, according to Eqs. 1 to 4, the B.O.D. of the waste is calculated to be 240 p.p.m., and that of the diluting water 0.6 p.p.m.

TABLE II.—Dissolved Oxygen Content Values Obtained, for Various Concentrations Prepared from Seeded Diluting Water, in Determination of Immediate and 5-Day B.O.D. Values of an Industrial Waste

Concentration of Sample (p.p.m.)	Dilution Factor	Diss. Oxygen Content (p.p.m.)	
		After 15 Min.	After 5 Days
0.02	50	6.6	1.4
0.01	100	7.0	3.9
0.005	200	7.2	5.4
0.002	500	7.4	6.3
0 (blank)	—	7.5	7.2

Summary

When seeded diluting water and low concentrations of samples are used, the B.O.D. of a waste should be determined from at least two different dilutions, giving suitable depletions of oxygen during incubation. In this way a system of equations similar to Eqs. 1 and 2 is obtained, from which the B.O.D. of the waste, as well as that of the diluting water, may be calculated. The calculation of corrected depletions from B.O.D. values of an incubated blank of the diluting water should be avoided.

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Industrial Wastes

RAYON WASTE RECOVERY AND TREATMENT*

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The battle against losses in essential materials in the rayon and cellophane businesses has been going on since those products were first manufactured on a commercial scale. The fact that these products are sold today in huge quantities at reasonable prices testifies that strict attention has been paid to efficient use of raw materials. It is safe to say that less rayon and cellophane would be sold today if reduction and recovery of wastes had not been practiced.

This paper discusses some of the more important steps that have been taken in the viscose rayon and cellophane processes of the Du Pont Company to keep the discharge of waste products within bounds.

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Manufacturing Process Steps

A short discussion of the major steps in the manufacturing processes is in order. Purified cellulose, in the form of cotton linters and wood pulp, is first steeped in caustic soda of about 17 per cent strength. The resulting alkali cellulose is reacted with carbon disulfide in large mixing vessels called barattes or churns (see Figure 1). The cellulose xanthate formed during this treatment is mixed with water and caustic solution to form a thick, viscous, clear dispersion, which is ripened to the proper extent to permit spinning or casting.

For rayon manufacture the viscose

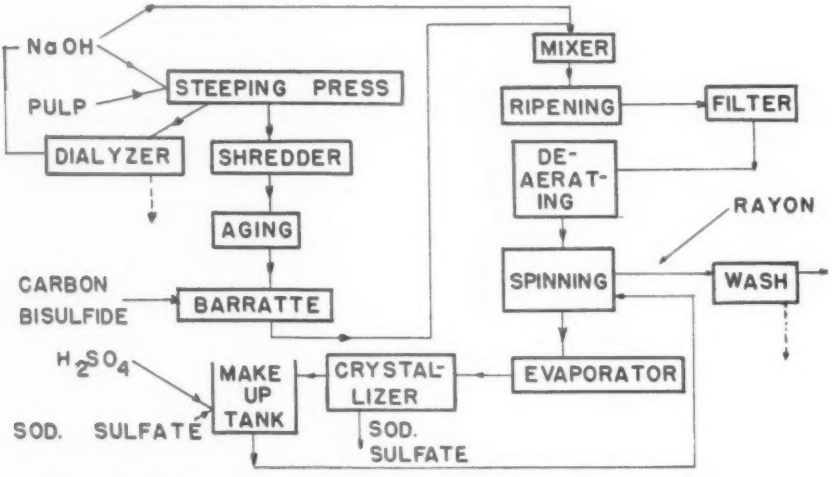

FIGURE 1.—Process flow sheet for manufacture of viscose rayon.

is forced through spinnerettes into a coagulating bath of sulfuric acid, and thence by way of guides and wheels to centrifugal buckets, which collect a certain amount of the twisted threads into a cylinder called a "cake." This cake passes through washing, bleaching, finishing, and drying operations before it can be shipped.

In making cellophane, the viscose solution is forced through a long thin slot to form a continuous film. This film also enters a sulfuric acid bath, where regeneration of cellulose occurs. The film passes continuously through several tanks for washing, bleaching, and softening, then is dried and rolled up on large rolls for further processing.

In both the rayon and cellophane processes, the caustic in the viscose is neutralized and extracted from it by the sulfuric acid during the step known as coagulation or regeneration. The sodium sulfate resulting from the neutralization remains in solution in the coagulating bath.

Sources of Wastes

The first source of waste in either process is discarded viscose, which comes from the cleaning of presses, the starting up of spinning or casting machines, and the occasional discarding of a sub-standard batch. Another source of waste material is the dialyzer solution from the rayon process, which contains some caustic and the bulk of the hemi-cellulose originating in the starting material—wood pulp or cotton.

Coagulating bath finds its way to the sewer in a number of ways. In the cellophane washtanks, it is discarded to keep the sodium sulfate content of the bath at the proper level. In the rayon process, the cakes remove some, some leaves with the crystallized sodium sulfate, evaporator entrainment causes some loss, bath filter backwashing accounts for more, and some enters the sewer from sources that can only be classed as miscellaneous. The bath lost to the sewer carries with it sodium sulfate, sulfuric acid, sulfur, glucose, and, in some cases, zinc sulfate.

Partially regenerated viscose is lost to the waste waters during machine start-ups and whenever trouble with spinnerettes is experienced. Not all of this material reaches the receiving waters, as a lot of it collects in sumps and manholes, which are cleaned periodically.

Finishing oils of various kinds are used to condition the yarn for further processing by weavers and other fabric producers. Some of these oils are water-soluble and reach the receiving waters in the wash waters following the finishing oil treatment.

In the cellophane process, solvents are used in the coating-solvent recovery operations. A small amount of these solvents are a source of B.O.D. in the wastes.

Other waste products, such as cinders and fly ash from the powerhouses, as well as lubricating oils, must be reckoned with. Sanitary sewage is, of course, the commonest waste and one which can easily be overlooked in an industrial plant.

Rayon Practices

The principal ingredients of the coagulating bath are sulfuric acid, glucose, zinc sulfate, sodium sulfate, water, and by-products produced by the coagulation of the viscose in the bath. The continuous formation of sodium sulfate prevents the addition of more sulfuric acid to the bath to permit its re-use directly. The build-up of salt cannot be tolerated beyond the point where crystallization occurs, because the crystals interfere with the spinning process. When the process first went into use, it was the practice to throw the bath away when the sodium sulfate content became too high. It was not long, however, before it was realized that the bath contained valuable constituents, which could be saved. The installation of evaporators and crystallizers was a natural outcome of

this realization. Both water and sodium sulfate are removed, because both show an increase during use of the bath. Since that time, pollution control efforts have been directed toward the elimination of all bath losses and toward an increase in the quantity of bath sent to the evaporators. To this end, all sources of leaks in troughs, pump glands, and handling equipment are watched carefully to prevent discharges to the sewers.

Filters have been installed to remove solid impurities from the bath and thereby permit more bath to be sent to the recovery system. Initially, the filters were backwashed with water as soon as their capacity dropped to a specific point and the contents of the filters were dumped to the sewer. Now they are given a careful displacement wash before being backwashed and the initial contents are sent to the recovery system.

Such minor items as evaporator entrainment losses and bath losses due to incomplete washing of crystallized sodium sulfate have been studied recently. Improvements in evaporator design have decreased entrainment losses almost to the vanishing point. Improved crystal washing methods now being worked out are expected to recover some bath now sent to the sewer with the crystals.

The principal reason for adding glucose to the coagulating bath is to prevent crystal formation on certain parts of the spinning machines. Glucose lost to the sewer adds B.O.D. to the plant effluent. With this in mind, studies have been undertaken which have resulted in a 50 per cent decrease in glucose consumption since 1937.

Caustic soda is used for steeping the wood pulp and cotton linters as the first step toward making viscose. During this steeping operation, hemi-cellulose is removed from the wood pulp. The hemi-cellulose has a substantial B.O.D. value and is an undesirable impurity in the steeping liquors. It must be removed from the spent caustic solution before that solution can be mixed with fresh caustic for further use in steeping. The caustic is purified by dialysis; the bulk of the hemi-cellulose with a small amount of caustic is run to the sewer. This waste liquor is one of the principal sources of B.O.D. of the rayon plant effluent.

A great deal of study has been given to the problem of reducing the amount of hemi-cellulose sent to the sewer. Attempts to convert it to a usable material or to extract it for disposal by burning or other means have been unsuccessful. The most effective means so far uncovered has been the efforts of pulp suppliers to increase the usable cellulose in their products. As the result of improvement in purity, the amount of hemi-cellulose sent to the sewer has decreased about 40 per cent.

Although sodium sulfate is not considered a polluting material in the amounts discharged from any of the Du Pont plants, many attempts have been made to utilize it in some measure. One outlet has been very successful, even though the amount of sodium sulfate consumed is relatively small. That is the substitution of the sodium sulfate for sodium chloride in the regeneration of the water softeners. It is true that the sulfate finds its way to the river just the same, but the discharge of a comparable quantity of chloride is prevented and the soluble salts reaching the river are therefore less. Water softeners at the Du Pont rayon plants have been regenerated that way for several years.

There is a constant demand for sodium sulfate in the paper industry, but it is preferred in the anhydrous condition (salt cake). The material produced in a rayon plant is Glauber's salt, with 10 molecules of water of crystallization. In normal times it is uneconomical to make the anhydrous salt by heating the Glauber's salt. During World War II, however, salt cake became very scarce and the paper industry would take any kind of sodium sulfate it could get. It was possible

for the rayon plants, at that time, to sell all of their Glauber's salt at an attractive price without even drying it. The situation has now reverted to normal.

Cellophane Practices

The manufacture of cellophane is on a continuous basis. The same approach to sewer losses has been used as was used in the rayon process. Every effort has been made to prevent leaks and to retain as much coagulating bath in the system as possible.

Washing of the cellophane film has become more efficient, with efforts aimed at keeping water out of the bath. This serves to retain the free acid in the bath system where it is useful. A recirculating system has been devised whereby the acid strength can be more closely controlled at the minimum concentration. This helps to reduce the amount of acid sent to the sewer.

Evaporators have been installed to remove water from the bath, thereby permitting greater re-use of the acid.

As the cellophane sheet moves continuously through the system, it tends to carry a substantial amount of liquid from one tank to another. Many different types of scrapers have been tried to prevent this carryover or drag-out. They have been perfected to the point where very little loss occurs from this cause. In certain purification tanks the temperature of the solution has been raised in order to decrease viscosities and thereby make the scraping job more effective.

The ingredient in the softener baths is generally glycerin or ethylene glycol, both of which have substantial B.O.D. values. The concentration of these ingredients must be carefully controlled. Many years ago, the water dragout from a previous tank diluted the softener solution so that some of it had to be discarded continuously. In studying this problem, it was found that water removal could be effected by evaporation to permit bath re-use.

Nitrocellulose is one of the materials used to coat the cellophane sheet. It is normally shipped in an alcohol-wet condition. The nitrocellulose is dissolved in a solvent before being applied to the cellophane and the alcohol becomes a part of the coating solution. The solvent is a mixture suitable for the solids used, and usually contains some alcohol and acetic ester.

When the film is passed through the drying tower, the solvents are removed from it by contact with hot air. To prevent atmospheric pollution and to save the solvents, the air is passed through activated carbon absorbers. Solvent is recovered from the carbon by steaming and the condensate then undergoes recovery by distillation.

It was found that hydrolysis of the acetic esters to acetic acid and alcohol could be minimized by more frequent steaming of the absorbers; therefore, this is done. The amount of solvent recoverable can be influenced by several factors, which have received careful study. In some cases, the solvent enters into side reactions and by-products are formed which defy recovery. Solvents are selected which do not have this undesirable characteristic.

Finally, ethyl alcohol is recovered from the solvent area wastes in a special still, which yields the alcohol in a denatured condition. In other words, the impurities acceptable to the Federal inspectors as denaturants are not removed. The alcohol can be shipped to a licensed denaturing plant, thus eliminating a corresponding amount of B.O.D. from the river.

General Practices

The greatest loss in viscose used to be that from starting up casting and spinning machines. The process of removing cakes from the spinning machines was also attended by a loss of partially coagulated viscose, because the machines cannot be shut down during the cake removal or "doffing" operation. The viscose loss during a cellophane machine start-up is now collected and returned to storage. The

main loss is from pump glands and from the residue left in the filter presses. Most of these losses are collected before they ever reach the sewer and the material is transported to the plant dump.

The loss in viscose during the process of cake removal on a rayon spinning machine can be a large one if the operator is careless. A good operator will see that no viscose gets into the sewer system because of "doffing," because he simply transfers the threads to a feed wheel, where they collect while he removes the finished cake. The feed wheel wraps are then removed as small hanks and are processed for sale as a special product.

In line with the policy of keeping waste viscose out of the sewers and the rivers, are the methods used to keep other materials in their proper places. Oils used in the process or for purposes of lubrication are collected and re-used or sent to the plant dump. The Old Hickory plant has recently installed an elaborate system for collecting and disposing of lubricating oils from the ammonia refrigeration system.

Cinders and fly ash are removed from the powerhouse gases and are settled out in conventional ponds, or are loaded in hopper cars for transfer off the plant grounds. The solids discharge to the river is improved thereby.

Some wonder may be expressed at repetition of such obvious facts in connection with the reduction of wastes. But the story should not be passed by without a closer look. The changes to equipment and to methods of operation sound exceedingly simple when discussed after the fact and away from the scene of operations. The truth is, however, that a tremendous amount of time and energy and a lot of money went into the solution of these problems. Quite frequently, the losses which are most obvious to the plant man are the most difficult ones to correct. There have been many opportunities for people to say, "Why didn't I think of that?" The fundamental advantage of the method of waste reduction described is that it has been possible to increase production at all of the company's plants through the years without a corresponding increase in the amount of wastes.

TABLE I.—Raw Materials Consumption at Old Hickory, Tenn., Rayon Plant

Material	Year	Lb. per Lb. of Rayon Production	Reduction (%)
Glucose	1929	0.31	
	1951	0.06	81
Zinc sulfate	1929	0.086	
	1951	0.028	67
Sulfuric acid	1929	1.77	
	1951	1.39	21
Caustic soda	1929	1.17	
	1951	0.92	21

Table I shows that large reductions have been made in unit consumptions of glucose and zinc sulfate. The magnitude of the reduction becomes more apparent when it is considered that the production of rayon has increased more than three times in the 22 years covered by the table. It is apparent that smaller reductions in sulfuric acid and caustic consumptions have been

TABLE II.—Plant Effluent Analyses at Spruance, Va., Rayon Plant

Material	Period	Reduction (%)
Zinc sulfate	1950—1st half	Base
	1950—2nd half	8.5
	1951—1st half	30.2
	1951—2nd half	37.9
	1952—1st half	39.9
B.O.D.	1950—2nd half	Base
	1951—1st half	16.6
	1951—2nd half	26.7
	1952—1st half	21.1
Sulfuric acid	1950—1st half	Base
	1950—2nd half	17.3
	1951—1st half	27.4
	1951—2nd half	25.0
	1952—1st half	41.2

made, since they are more closely tied in with production.

The data of Table II are of recent origin. The waste reduction program at Spruance, Va., has been given new impetus by the successful functioning of the Virginia State Water Control Board. The Board usually requests improvement in effluent quality in some degree whenever a permit request is made for higher production of rayon or cellophane. So far, the lower quotas have been met without resorting to treatment of the over-all waste. It is sincerely hoped that that state of affairs will continue, although the situation gets tighter all the time.

Treatment a Last Resort

The key to the whole waste reduction program is a management earnestly desirous of reducing pollution by all reasonable means and the setting up within the plants of waste recovery groups that really feel they have an important job to accomplish. One of the functions of these groups is to create a desire on the part of the operators and foremen to see the waste reduction program succeed. Until the man who turns the valves sees the picture clearly, the whole program fails. When efforts to get the job done by process improvements fail, it is necessary to resort to waste treatment—usually at greater cost. It is the author's philosophy that treatment should be a last resort and not the first thought of the waste disposal engineer. Treatment is expensive and rarely do the products of treatment yield monetary returns.

The Du Pont Company operates plants on three sites at which rayon and cellophane are sister products; on the James River in Virginia, on the Cumberland River in Tennessee, and on the Niagara River in New York. It is fortunate that these are all fairly large rivers, comparatively speaking. They all have sufficient alkalinity to absorb the free acid in the plant effluents without damage to water quality or to downstream consumers. They all have flows large enough to receive the other alien factors, such as B.O.D., sulfates, and some colloidal sulfur, without being inordinately affected for subsequent use. These plants are also fortunate in being located in states where the officials administering the anti-pollution laws are both sensible and fair in their dealings with industry and industrial effluents. They subscribe, and rightly so, to the theory that a body of water is polluted only when it receives too much of an alien substance. There is, of course, ample opportunity for argument on the question of what constitutes too much. The important thing is to agree that the particular river or body of water has a self-purifying capacity, which should be utilized to the greatest benefit of all.

This does not mean that the industrialist should be favored over the municipality, or that one industry should be favored over another. It simply means that the treatment capacity of the waters should be apportioned fairly among those who need it in order that all may benefit from reduced costs. There are some people naive enough to believe that when industry is forced to spend large sums for waste treatment it does not concern them. The bill that industry has to pay for waste treatment, they believe, comes from some intangible source that will only succeed in reducing profits which are already too high. These same people are keenly aware of the cost of municipal sewage treatment when their tax bill stares them squarely in the face. The facts of the matter are simple, however, and any unbiased observer can understand them. Industry as a whole must earn a reasonable rate of return on its entire investment, whether it is lodged in real estate, buildings, manufacturing equipment, or waste treatment units. Operating expenses, which are made up of costs for raw materials, labor, utilities, packages, etc., are deducted from revenue before taxes and net profit.

If costs for waste treatment or disposal are incurred, these too must come out of gross income. If the amount remaining after taxes is not enough to yield a reasonable return on the entire investment, the plant or industry must raise the price of its product or it must go out of business. In any event, some segment of the population must foot the bill. All people are a part of the picture and all must pay a fair share for pollution abatement. That cost cannot always be seen as clearly as the municipal tax bill or sewer rental charge, but it's there just the same.

This is not an argument against pollution abatement or against spending money to correct it. It is only an argument against unreasonable demands regarding the degree of treatment required for municipal and industrial wastes and a further argument against the setting up of arbitrary and restrictive effluent quality requirements.

The Du Pont Company has been fortunate at its rayon and cellophane plant locations because the requests of the control agencies have been temperate and sensible and have been dispensed in a spirit of cooperation. Under these circumstances, it has been possible to work slowly but steadily toward the goal of satisfactory effluent quality with assurance that the recovery methods as worked out were sound and that they would bring about the desired results.

Acknowledgment

The assistance of B. L. Strother, W. J. Eldridge, and C. A. Davis, respectively in charge of waste studies at Du Pont's Spruance, Old Hickory, and Yerkes plants, is gratefully acknowledged.

DISCUSSION

By C. E. Renn

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The history of waste reduction in the viscose rayon industry has been described in a very vivid fashion by Mr. Jacobs. There has been growth of our knowledge of the behavior of treated and untreated wastes in receiving waters, also. The following discussion presents a few notes on the problems of waste assimilation in streams.

In part, the assimilative capacity of the receiving waters is determined by the physical characteristics and flow patterns of the streams themselves. These limits also characterize other wastes of comparable physical characteristics. If the combined wastes of the plant are discharged at a common outfall, a relatively warmer, more saline waste stratum will be produced in the immediate vicinity of the discharge. The specific gravity of viscose waste, due to its sodium sulfate content, is higher than that of fresh waters. The elevated temperature of untreated waste, in the range 32° to 40° C., yields an effluent which is less dense than the fresh waters of large streams at temperatures of 25° C. or less.

Some interesting mixing problems follow from this. If the waste is discharged into a large, slow-flowing stream, the effluent first flows out along the surface as a sheet of light water. In this site it is highly vulnerable to wind movement and its ultimate path is more likely to be determined by wind direction than by the slow river flow. It will be moved up-, down-, and across-stream with the winds. As this light, superficial layer cools through heat loss to the air and to the underlying water, however, its density increases and it mixes more readily with the underlying stream water. As it approaches the stream's water temperature, it "falls" in a complicated rain-

like eddy pattern through the supporting waters and mixes readily with them.

Under most conditions, this produces mixing in slow-flowing streams that is much more rapid than could be obtained if the wastes were initially of the same temperature as the receiving waters. Density streaming has been substituted as a method of mixing for the low turbulent energy potential of slow, deep waters. This mechanism is undoubtedly important for the mixing of all types of warm saline wastes in tidal streams. It deserves detailed study wherever outfalls are planned for tidal receiving waters.

The behavior of a relatively warm, saline waste in a shallow, rapid stream is quite different. Here the difference in viscosity of the warm waste and the cooler stream water limits the rate at which waste can mix across the stream. If major discharge is made at one side of the receiving stream, the wastes tend to cling to the plant side more tenaciously than they would if they were of the density and temperature of the receiving water. One effect of this dispersal limiting mechanism is to concentrate very warm wastes along the plant shore line. Temperatures of the waste may be high enough to damage aquatic life in these areas. Obviously, it is necessary to disperse such warm wastes through multiple outfalls arranged to take advantage of turbulent mixing in the immediate vicinity of the outfall. Cooling in treatment, in transit, and in lagoons becomes advantageous.

The behavior of receiving waters under the organic loading imposed by rayon wastes is very much like that anticipated from comparable loadings of domestic sewage, although composited rayon wastes are comparatively low in available nitrogen. Wastes are, of course, much more diluted than domestic sewage. There are no special problems associated with the organic components of the wastes in the stream themselves that are unique to the industry. Sometimes discharge of soaps and synthetic detergents shows as a white film or crust on the shores below the outfall, but these disappear after mixing, and in the low dilutions produced in the receiving waters no evidences are found of refractory residues.

The most unusual problems of the viscose rayon wastes are associated with certain special rayons that yield zinc-bearing effluents. The history of zinc wastes is extremely turbulent, with a long, bitter background in the mining industry of Wales and the northern United States. Until recently, there has been no firm fundamental information upon which to base the capacity of streams to assimilate zinc residues. In the first place, measurements of small quantities of zinc have been unreliable because of multiple interferences of silt and of other metals with sensitive colorimetric methods that must be employed for practical waste control. The industries have done a large amount of analytical research to improve the method and there are now available several good, practical methods for determining zinc in the range of a few hundredths parts per million that were not available before.

One outcome of the work on zinc in wastes has been a much better understanding of the zinc utilization and loss budget in the plant proper.

Secondly, until recently there was no satisfactory picture of the ultimate fate of zinc in the receiving waters themselves. It was proposed during the Welsh controversy that zinc sulfate was alternately reduced to zinc sulfide and oxidized to soluble zinc sulfate with changes from anaerobic to aerobic conditions in the stream and in ore dumps. Thus, the concept of a perpetually zinc-plated stream bottom rose to plague waste engineers.

Work by two leading rayon-producing companies shows that zinc is ad-

sorbed strongly and permanently upon silt, and that silt adsorption is a significant mechanism for inactivating zinc that reaches the stream. It is worth considering what relation silt bears to the metallic salts in the other types of wastes, especially since industry is moving into areas where the larger rivers are more or less permanently silty. It is possible, as one of the leaders in the wastes treatment field has pointed out, that these silty waters may have special values to industry.

Thirdly, as often happens during practical investigations of the order met in waste studies, great deficiencies are found in the fundamental information. As pointed out earlier, it was found that more sensitive and reliable analytical methods are needed. It also was found that early published data on the solubility of zinc salts at varying pH's and in association with other ions was inadequate. It has been necessary to carry out basic studies on the true solubilities of zinc salts.

Fourthly, a great deal also has been learned about the ways that viscose rayon wastes act upon the animal communities of a stream. In the case of zinc-bearing wastes, for example, it was found that a number of aquatic invertebrates common to the stream bottom are more sensitive to zinc than fish are. In one case this has led to a system of continuing river surveys, in which the performance of the waste abatement program is judged by the life of the stream itself. These surveys are important supplements to the operating and performance data of the plant.

Studies of the bottom communities are also furnishing data from which the adequacy of various types of waste abatement programs may be judged. These decisions are based upon the response of the receiving waters themselves.

PILOT PLANT FOR TREATMENT OF KRAFT MILL WASTES

By W. A. Moggio and H. W. Gehm

Resident Engineer, National Council for Stream Improvement, Louisiana State University, Baton Rouge, La.; and Technical Director, National Council for Stream Improvement, New York, N. Y.

A pilot plant to investigate the feasibility of biological treatment of kraft mill wastes was constructed and began operation in September, 1951. The site of the pilot plant is the Macon Kraft Company mill in Macon, Ga. The design, supervision of construction, and operation of the pilot plant is the joint undertaking of the National Council for Stream Improvement and the Macon Kraft Company. Financing of the construction is the joint undertaking of a group of southern kraft pulp and paper manufacturers and the Macon Kraft Company. The total cost of the pilot plant amounted to approximately $23,000, of which $9,000 was contributed by companies other than the Macon Kraft Company, the remainder having been contributed by the latter. Operating and maintenance costs are shared by the National Council for Stream Improvement and the Macon Kraft Company, the former contributing the services of a full-time resident engineer charged with the operation of the pilot plant and the latter furnishing the maintenance and minor changes needed for the efficient operation of the pilot plant. Planning and supervision of operation is a function of National Council for Stream Improvement engineers.

The purpose of the pilot plant is to investigate, on a much larger scale, the principles of biological treatment of kraft mill wastes which had previously been developed on a laboratory scale (1). Operation of the plant is directed toward the compilation of data for later evaluation as to the efficacy of this treatment process for full-scale application. The information obtained will be used to determine the construction and operational costs of this method of treatment if the process is to be applied on a full-scale treatment basis.

The operational plan for the pilot plant is designed to study the many variables involved in the treatment of kraft mill wastes by a process which is similar to the treatment of domestic sewage by activated sludge. The following factors are to be extensively investigated:

1. Nutrient requirements.
   a. Nitrogen and/or phosphorus.
   b. Minimum concentrations required.
   c. Point of nutrient addition.
2. Aeration periods.
3. Air requirements per gallon of waste treated.
4. Biological solids concentration.
5. Excess sludge formation and methods for its disposal.
6. Effect of shock loads on treatment efficiency.

Types of waste to be studied include the mixed kraft mill effluent and individual waste effluents from selected sources. In addition, it is planned to investigate the treatment efficiencies of various modifications of the activated sludge process, as well as the treatment of kraft mill wastes with combinations of this accelerated treatment and ponding. The latter will include partial treatment of the wastes,

TABLE I.—Characteristics of Mixed Kraft Mill Waste as Received at Pilot Plant

	Min.	Max.	Av.
B.O.D., 5-day, 20° C. (p.p.m.)	72	605	298
Oxygen cons., $KMnO_4$ (p.p.m.)	130	840	485
Color	400	1,800	800
Temperature (°C.)	30	44	38
Suspended solids (p.p.m.)	20	186	65

using aeration, followed by ponding of the effluent for the completion of the treatment.

Characteristics of the mixed kraft mill wastes selected for the initial investigation are presented in Table I.

Design Features

The pilot plant, the flow diagram of which is shown in Figure 1, consists of an aeration tank, a clarifier, an air blower, an air-lift sludge return device, a pump for returning treated waste and excess waste flows to the mill's regular disposal system, nutrient feed equipment, flow measurement weirs, and recorders. A frame building contains the controls, the nutrient feed equipment, and the laboratory test equipment. All units stand on or above ground level (Figure 2).

The aeration tank, constructed of reinforced concrete, is 28 ft. long, 13 ft. deep, and 5 ft. wide. A freeboard of 1 ft. is allowed, making the liquid depth 12 ft. The tank walls are beveled near the liquid surface and at the tank floor to assist in inducing a spiral flow. Air diffusers are located in a longitudinal row near one side and at the bottom of the aeration tank. The diffusers, six in number, are made from drilled pipe and are connected to an air header at the top of the aeration tank by a union, permitting easy removal in the event that cleaning becomes necessary. The influent end of the aeration tank is equipped with weir boxes for measurement of the waste and return sludge flows to the aeration tank through a mixing chamber. Capacity of the aeration tank is 12,600 gal. (Figure 3).

The blower supplying the air to the aeration tank delivers up to 100 c.f.m. of free air at a pressure of 6 p.s.i. This blower also furnishes the air required for the return sludge air lift.

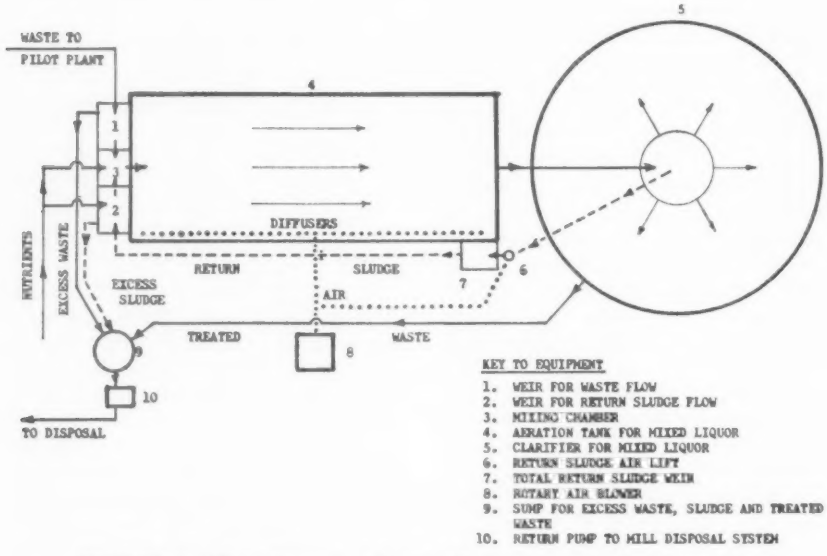

FIGURE 1.—Flow diagram of kraft mill waste treatment pilot plant.

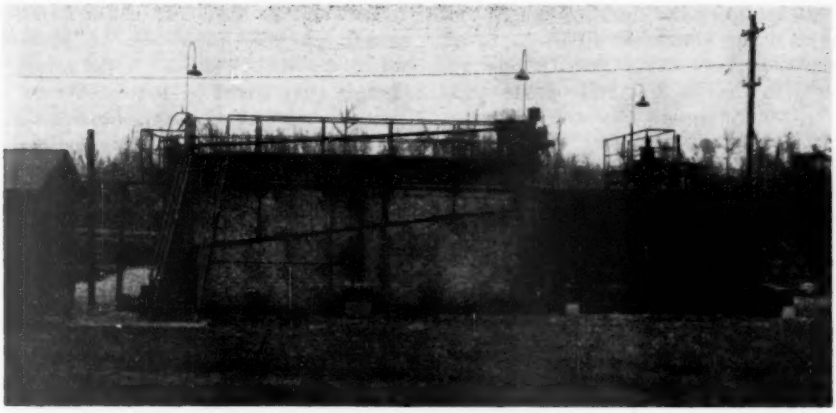

FIGURE 2.—Activated sludge pilot plant at Macon Kraft Company mill in Macon, Ga. Rotary blower is in front center.

The radial-flow clarifier, constructed of steel, is 20 ft. in diameter with a liquid depth of 7 ft. 4 in. It is equipped with a peripheral weir and a sludge collector mechanism. Capacity of the clarifier is 17,225 gal. This capacity is greater than would be desired, but since the clarifier was available at the site it was decided to utilize it, particularly in view of the shortage of equipment and extended delivery dates on account of the national emergency.

Sludge is removed from the bottom

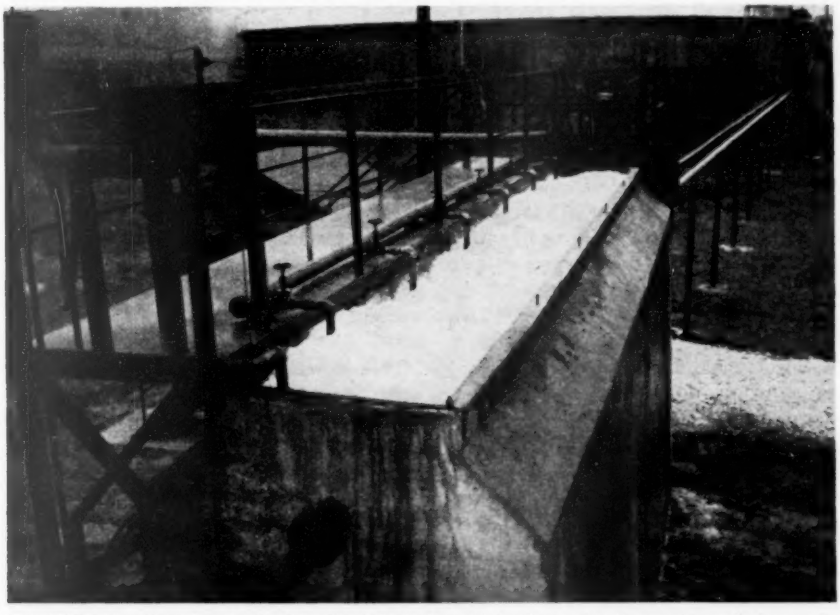

FIGURE 3.—Aeration tank of activated sludge pilot plant, showing return sludge weir box (left foreground) and equalizing tank (background).

center of the clarifier through a 3-in. pipe. The sludge is air-lifted to an elevation permitting gravity flow return to the influent end of the aeration tank, through two weir boxes.

The pilot-plant effluent, excess waste coming to the pilot plant, and excess sludge are collected in a common sump. From there they are returned to the mill's regular waste disposal system by means of a centrifugal pump.

Nutrient chemicals are fed either into the mixing chamber or the return sludge weir box at the influent end of the aeration tank. Monosodium phosphate solution is fed into a constant-head solution feeder by means of a small centrifugal pump, which recirculates the overflow from the feeder and the chemical solution reservoir. Ammonia is fed in at the same points by means of an ammoniator. Both feeding devices are manually adjusted.

Flow Measurement

Waste Water

Waste water entering the pilot plant is measured through a 90° V-notch weir. The weir is so constructed that the waste enters the weir box in a stilling well, one side of which is a baffle and the opposite side an adjustable gate. The gate is raised or lowered to regulate the flow over the V-notch weir. The excess waste overflows the adjustable gate and flows through a pipe to a sump, from whence it is returned to the mill's regular waste disposal system. The measured waste flows over the V-notch weir into a mixing chamber prior to entry into the aeration tank. Continuous flow records are obtained by means of a level recorder installed on the weir box. Discharge of waste into the mixing chamber is by free fall.

Return Sludge

Return sludge flows are measured at two points in order that suspended solids concentration of the mixed liquor in the aeration tank could be controlled and so that data could be obtained on the quantities of excess sludge to be disposed of. Total return sludge is measured by means of a 60° V-notch weir immediately following the air lift. The sludge is discharged into a surge tank from the air-lift device, then flows into the weir box equipped with a level recording device. Sludge returned to the aeration tank, via the mixing chamber, is measured through another 60° V-notch weir, which is the counterpart of the waste flow weir previously described. Excess sludge flows into the same sump as the excess waste and is disposed of in a similar fashion. The quantity of wasted sludge is obtained by difference between the two recorded sludge flows.

Air

Air flow to the aeration tank, through the diffusers, is measured by means of an orifice plate in the air header. A recorder furnishes a continuous record of this flow. Not included in the record is the air used in the air-lift device, only the air to the diffusers being measured.

Operating Details

Start-up of the pilot plant was accomplished by gradually increasing the proportion of waste added to the aerated seed organisms. The seed organisms were obtained from a nearby Air Force base and consisted of humus sludge from a secondary clarifier following a trickling filter. Approximately 1,000 gal. of this material was used.

Waste waters to the pilot plant originate presently at two sources. One source is the total mill waste, which comes from a 1-m.g. capacity equalization tank by gravity flow through a 4-in. pipe. The second source of waste is evaporator hot-well water, which also flows by gravity through a 4-in. pipe. The waste waters from these two sources are not mixed, but are treated separately at the pilot plant.

Initial operating plans call for the

operation of the pilot plant in a manner similar to activated sludge treatment. Kraft waste enters the aeration tank over a measuring weir and through a mixing chamber, where return sludge mixes with waste. The mixed liquor is then aerated for the required period in the aeration tank. Following the aeration the mixed liquor flows by gravity into the circular clarifier, where the sludge settles. The supernatant overflows the peripheral weir and discharges into a sump, where a pump returns it to the mill's regular waste disposal system. The settled sludge is returned to the influent end of the aeration tank by means of an air-lift device, passing over one weir for the measurement of total return sludge and over a second weir where the excess sludge is wasted and the required return sludge is mixed with the incoming waste in the mixing chamber. Excess sludge, wasted continuously, enters a sump and is returned to the mill's waste disposal system by the same pump that returns the treated effluent.

Operation of the pilot plant is on a continuous 24-hr., 7-day per week basis. During mill shutdowns, the pilot plant is operated to the extent that sugar is added to the aeration tank, along with the necessary nutrients, to maintain sludge activity.

Design of the pilot plant is such that its operation permits the study of kraft waste treatment through a wide range of aeration periods, air quantities, nutrient requirements, and suspended solids concentration. Its design is flexible enough to permit studies of kraft waste treatment in combination with other biological or chemical treatments, as well as by modifications of the activated sludge process.

One operator, working only the day shift, operates the plant, runs the control tests, and maintains the records. During the two remaining shifts the pilot plant runs without an operator. Operation is checked, however, several times during this period by mill personnel who operate the mill's water treatment plant. Operation during week ends is on the same basis as the off-shift operation.

TABLE II.—Types and Schedules of Control Tests

	Infl.	Effl.	Ret. Sl.	Mix. Liq.
B.O.D.[1]	x	x	—	—
Oxygen cons., $KMnO_4$[1]	x	x	—	—
Rel. stability[1]	—	x	—	—
Dissolved oxygen[1]	x	x	—	x
Suspended solids[1]	x	x	—	x
Total solids[1]	—	—	x	—
Volatile	—	—	x	—
Ash	—	—	x	—
Sludge index[1]	—	—	x	—
Temperature[2]	x	x	—	—
Color[1]	x	x	—	—
pH[2]	x	x	x	—
Nitrogen[1]	x	x	x	—
Phosphorus[1]	x	x	x	—

[1] 4-hr. composite, daily.
[2] Spot, daily or occasional.

All control valves, weirs, and gates are located on a walkway constructed along the top of one side of the aeration tank. This greatly facilitates the operation of the plant. Similarly, all electrical control switches, and recording and indicating meters are located in the control building adjacent to the pilot plant.

No provision is made for sludge digestion, as laboratory work indicated that excess sludge would occur only in small quantities and there is no primary sludge to be digested.

Sampling, Testing, and Records

Samples are all collected by the operator, who also does all of the testing and maintains all of the records. Sampling and testing are confined to the shift when the operator is present, and generally, no samples are collected on week ends. Exceptions to this procedure are made, naturally, as the occasion may demand.

Spot and composite samples are both collected for testing purposes. Types and schedule of the control tests are shown in Table II.

Records of the pilot-plant operation are compiled and maintained by the operator. Daily operating records are consolidated and distributed weekly to personnel concerned with the pilot-plant operation.

Acknowledgments

The authors gratefully acknowledge the suggestions and assistance rendered in the design, construction, and operation of the pilot plant by D. G. Terry, Mead Corporation; H. Kidd, L. C. Crowder, and L. E. Goodwin of Macon Kraft Company; and A. J. Palladino of the National Council for Stream Improvement.

Reference

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UNITED STATES–MEXICO BORDER PUBLIC HEALTH ASSOCIATION TO MEET

The United States-Mexico Border Public Health Association has announced its 11th Annual Joint Meeting, to be held in El Paso, Texas, and Ciudad Juarez, Chihuahua, Mexico, April 8–10, 1953.

Represented in the Association are federal public health and stream pollution abatement agencies of both the United States and Mexico, as well as state and local agencies of Texas, Arizona, California, New Mexico, Tamaulipas, Nuevo Leon, Coahuila, Chihuahua, Sonora, and Baja California.

DETERMINATION OF PHENOLS BY THE p-NITRO-SODIMETHYLANILINE METHOD—A DISCUSSION

By I. Nusbaum

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In the recent paper by Hill and Herndon (1) the indophenol method for the formation of strongly colored compounds by the reaction of phenol and a paraphenylene diamine in the presence of an oxidizing agent has been carefully detailed. As noted by the authors, the method is essentially that of Houghton and Pelly (2) first published in 1937. The method is sensitive, rapid, and subject generally to the same disadvantages and interferences of the other determinations for trace amounts of phenolic compounds. Hill and Herndon, using E. K. Co. Cat. No. 188 p-nitrosodimethylaniline, were able to prepare a somewhat stable reagent, which then required reduction to the p-aminodimethylaniline just prior to use in the reaction. The oxidizing agent used is a sodium hypochlorite solution, the addition of which must be carefully controlled, as an excess will result in a bleaching of the indophenol. Sulfides and aromatic amines form the principal source of interference in this reaction, as they apparently do in the Gibbs and 4-aminoantipyrine reactions. Distillation of the phenol from an acidified sample is still recommended as the most satisfactory procedure for the separation of the phenols from the interferences.

Because of the basic simplicity of the test and the availability of reagents, the writer has used the procedure for several years and has developed a modification, which is believed to eliminate many of the difficulties inherent in the frequently used tests for phenolic compounds.

Eastman Kodak Co. recently introduced a new oxalate salt of p-aminodimethylaniline (Cat. No. 5672). This reagent does not oxidize and discolor rapidly when the material is exposed to air as do the free base and the hydrochloride and sulfate derivatives. The p-aminodimethylaniline oxalate remains unchanged for an indefinite period. It thus provides the first step in the preparation of a stable reagent not requiring initial reduction. It was then found that a 0.1 per cent solution of the amine salt as the free base in a 1 per cent sulfuric acid solution remained stable indefinitely. No deterioration has been found after standing several weeks. The 0.1 per cent solution is prepared from a stock solution of 6.5 g. of the amine salt in 1:1 sulfuric acid, made up to 25 ml. This stock solution may discolor slightly on standing, but its usefulness remains unimpaired.

An oxidizing agent was required that would catalyze the reaction, but when present in excess would not interfere. It was found that potassium ferricyanide solution, as used in the 4-aminoantipyrine reaction (3), would serve admirably. The potassium ferricyanide also provided a solution to one of the major sources of interferences, sulfides. As shown later, the ferricyanide reagent may be added to the sample prior to the addition of the amine reagent. The ferricyanide destroys the sulfides and permits the reaction to proceed without interference from that source.

The writer also has found that it becomes virtually possible to eliminate

the necessity for distillation of the sample where the remaining interferences are principally aromatic amines. It was found possible to reduce the concentration of these amines below that where the formation of an indamine would interfere. Strongly acidic ion exchange resins, such as Dowex 50-X-8 or Amberlite IR-112 (H), are known to be effective in removing amino-compounds from solution. A small amount of the resin, stirred for 3 to 5 min. with the sample, will effectively remove interfering quantities of aromatic amines. This technique may also be applied to the Gibbs and 4-aminoantipyrine reactions.

The simplified procedure for the determination of phenols may then be performed as follows:

1. Reagents

All chemicals should be of reagent grade.

1.1. Borax, saturated solution at 20° C. (approximately 2.7 g. per 100 g. water).

1.2. Potassium ferricyanide solution, 8 per cent.

1.3. A 0.1 per cent p-aminodimethylaniline oxalate solution, as the free base in 1 per cent sulfuric acid. 1 ml. of the stock solution diluted to 200 ml. with distilled water containing sufficient sulfuric acid to make the final concentration 1 per cent H_2SO_4.

1.4. Ion exchange resins, either Dowex 50-X-8 or equivalent, or Rohm and Haas Amberlite IR-112 (H).

1.5. Iso-amyl alcohol, carbon tetrachloride, or chloroform.

1.6. Standard phenol solution, 1,000 mg. per liter.

2. Procedure

2.1. To a sample containing at least 5 micrograms and up to 40 micrograms of phenols, add 5 ml. of the borax buffer. Add the 8 per cent ferricyanide solution in a volume equivalent to the volume of the amine reagent to be introduced subsequently.

2.2. Add 2 ml. of the amine reagent for samples up to 100 ml., and 4 ml. of the reagent for sample sizes greater than 100 ml., and shake. The final pH of the mixture should be from about 8.3 to 8.7 and experience will indicate whether the amount of buffer solution should be varied slightly to meet this requirement. Allow the color to develop for at least 15 min. and extract with a predetermined aliquot of either isoamyl alcohol, carbon tetrachloride, or chloroform. The procedure of Hill and Herndon (1) using series extraction with 10- and 5-ml. portions of iso-amyl alcohol or serial extraction with the other solvents mentioned works very satisfactorily. However, there appears to be less effect upon the carbon tetrachloride or chloroform extracts from the addition of varying quantities of the amine reagent than upon the iso-amyl alcohol extract. Where the concentration of phenols is very small, it may be necessary to use 5-cm. cells in the spectrophotometer or filter photelometer, or to use Nessler tubes. Calibration curves should be developed for both 1- and 5-cm. cells if concentrations below 20 p.p.b. are to be determined. The wavelengths recommended by Hill and Herndon (1) are satisfactory for this determination.

2.3. Where interference from aromatic amines may be suspected, approximately 5 g. of the Dowex 50 or IR-112 (H) should be added to the sample and agitated for 3 to 5 min. A portion should then be filtered and the procedure of 2.2. followed. Should the sample contain excessive concentrations of dissolved salts or amines, it may be necessary to repeat the process. The resins may be regenerated with sulfuric acid, in accordance with the directions of the manufacturer.

3. Notes

The p-aminodimethylaniline oxalate is an exceptionally stable diamine salt, which the writer has used in other tests with satisfactory results. The 0.1 per cent reagent used in the phenol method may also be used for the detection and

determination of available chlorine and the amine salt may be used to prepare the amine reagent for the determination of sulfides by the formation of methylene blue.

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RADIOACTIVE WASTE DISPOSAL

A safe and comparatively simple method of radioactive waste disposal is described in a recent article by Clinton C. Powell and Howard L. Andrews (*Pub. Health Rep.*, **67**, 12, 1214; 1952), of the National Institutes of Health, U.S.P.H.S.

The present system for disposal of radioactive wastes too active to put into municipal sewers or in forms not suitable for liquid disposal is the result of more than 2½ years of experimentation with various containers and methods of sealing. Steel drums and garbage cans were both determined to be unsuitable containers because they roll if placed on their sides, are inconvenient to handle, and disintegrate rapidly in sea water.

Standard, commercially available, concrete burial vaults were found to be satisfactory basic containers. Child-size vaults, 19¾ by 18¾ by 44 in. (outside), hold about 5.3 cu. ft. of material and cost about $25 each. Vaults also are available in larger sizes, up to 36 by 28 by 93 in., for disposal of large items of equipment not readily broken down, but the small size is more generally useful and more easily handled. The vaults may be lifted by steel cables attached to the four lifting eyes cast in the bottom. Pending disposal, they occupy a minimum of space and may be stacked if allowable floor loading permits.

The waste products are packed in the vaults, with bulky materials being reduced by cutting or dismantling, or by concentration. The vaults are filled to within 3 or 4 in. of the top, then filled flush with high-slump concrete. Voids are filled as completely as possible to decrease buoyancy and the possibility of crushing by external water pressure.

Although ultimate disposal is preferably by dumping at sea in depths of at least 1,000 fathoms of water, the vaults also are useable for land burial. If sealed as described, contact between the active contents and surrounding earth and water is minimized, and removal is facilitated if a new burial site must be used.

In sea disposal, each discarded vault represents almost a monolith that probably will not disintegrate appreciably in 100 years. Contamination by diffusion should be very small, even if the seal between the cement cap and the vault body is not watertight, and dilution by surrounding sea water should be great. Natural decay of the radioactivity will be so greatly reduced that any undecayed products left by the time the block eventually crumbles would have negligible effect on the large volumes of diluting sea water.

COLOR IN INDUSTRIAL WASTES

V. Chlorination for Color Removal *

By Willem Rudolfs and William D. Hanlon

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Chlorination has been used rather extensively for color removal processes, commonly referred to as bleaching. In view of the successful application in other fields, a study was made concerning the effectiveness of chlorination for industrial waste color removal.

The extent of chlorine treatment for bacterial kill is based upon maintaining a definite chlorine residual, which in turn is based upon the chlorine demand or chlorine consumption of the sewage or waste. Usually, the chlorine necessary to provide 0.1 p.p.m. chlorine residual following a 15-min. contact period is sufficient to cause desired kill.

It has been shown (3) that the chlorine demand of an industrial waste is only a fraction of the total amount of chlorine necessary for complete reaction. For bacterial kill purposes, involving concentration and contact time, the chlorine demand is of value. However, its application to the chemical reactions involved in bleaching is questionable.

Preliminary work indicated that the total quantity of chlorine required for reaction with an industrial waste may be determined by superchlorination. By this method, the difference between the amount of chlorine added and the residual following a specific contact period is determined as the chlorine utilized by the waste. This value, designated as the "chlorine utilization," may conceivably show a relationship be-

* Paper of the Journal Series, New Jersey Agricultural Experiment Station.

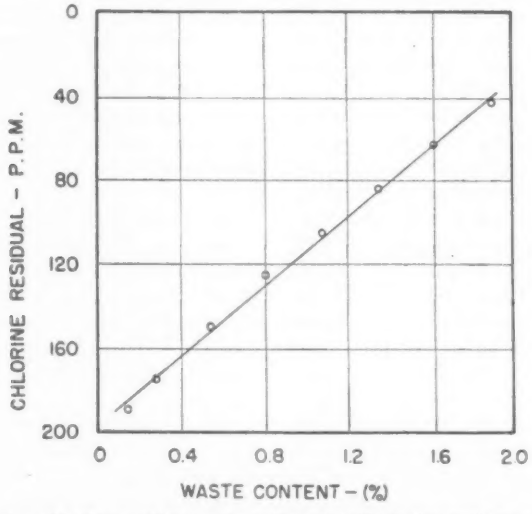

FIGURE 1.—Chlorine residual values (starch iodide) for various quantities of rope cooking liquor waste.

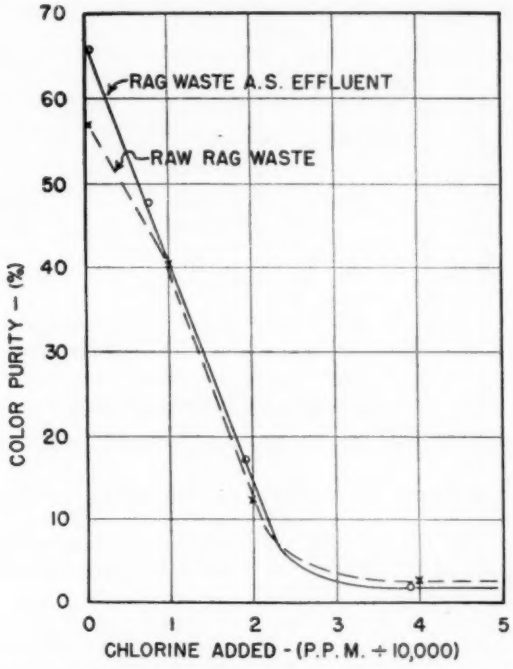

FIGURE 2.—Effect of chlorination on color characteristics of raw and activated sludge treated rag cooking waste.

tween the chlorine utilized by an industrial waste and the quantity of chlorine required for maximum color reduction.

Chlorine Residual and Color Removal

Figure 1 represents the chlorine residual (starch iodide) for various amounts of a rope cooking liquor waste superchlorinated to the same extent and allowing a 1-hr. contact period. The slope of the curve indicates that the chlorine utilization by the rope waste was about 8,200 p.p.m. Subsequently, it was found that the chlorine utilization values for gum and rag cooking liquor wastes were of little value for the control of color reduction by chlorination.

This is illustrated by the rag cooking liquor color reduction curves in Figure 2, which show that approximately the same quantity of chlorine was required for the same degree of color reduction in both the raw rag waste (3,000 p.p.m. B.O.D.) and the rag waste activated sludge effluent (250 p.p.m. B.O.D.) The chlorine utilization reduction by biological treatment was approximately 40 per cent, indicating that there was no direct relationship with the quantity of chlorine required for color reduction. Subsequently, the chlorine color reduction requirements were based on the color intensities of the individual wastes. Since there was a correlation between chlorine utilization and 5-day B.O.D. values, it may be worth while to use the relationship in problems where immediate B.O.D. estimations are desired.

Free Chlorine *vs.* Sodium Hypochlorite

To determine the relative effectiveness of free chlorine and hypochlorites for waste color reduction applications,

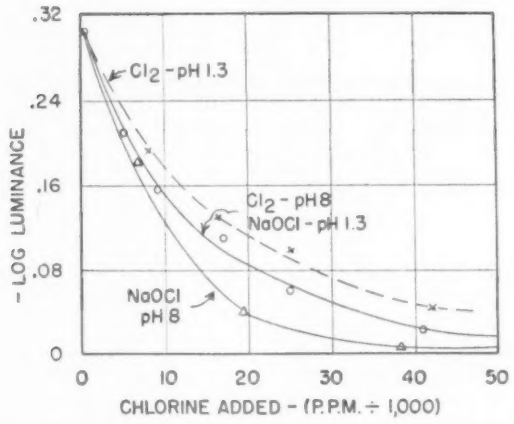

FIGURE 3.—Relation between chlorine utilization and color characteristics of rag waste.

dilute rag cooking liquor waste effluents from an activated sludge process were treated at pH 1.3 and pH 8.0 with various amounts of chlorine in the form of chlorine water, and sodium hypochlorite. Following a 6-hr. contact period in open vessels, the chlorinated samples were adjusted to pH 7.6 and filtered for color determinations. The chlorine additions were on the basis of the raw concentrated rag liquor (27,000 p.p.m.)

From the results (Figure 3) it is apparent that for the same pH value, NaOCl was more effective than chlorine water for reducing the color of the rag cooking liquor waste. Furthermore, both NaOCl and chlorine water were more effective at pH 8 than at pH 1.3. These results might be explained in two ways. First, the form of chlorine (HOCl) at pH 8 may have been more effective for color reduction than free chlorine at pH 1.3. Second, at the lower pH values, there was a greater loss of the relatively volatile HOCl and free Cl_2 to the atmosphere. It would be expected that the loss of free chlorine to the atmosphere would be affected by the concentration of soluble material present in the waste.

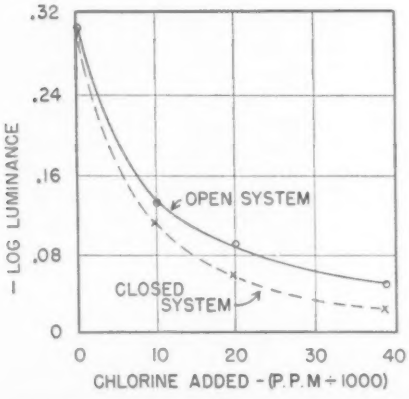

FIGURE 4.—Comparison of chlorination in open and closed systems.

Chlorination in Open and Closed Systems

It can be expected that considerable chlorine losses occur as a result of chlorinating in open systems. To determine the extent of such losses, duplicate aliquots of a rag cooking liquor waste effluent from an activated sludge process were adjusted to pH 7 and chlorinated (chlorine water) to various degrees at room temperature. One group of chlorinated aliquots was held in open vessels while the remaining group was kept in glass-stoppered bottles. After a 5-hr. contact period, all samples were adjusted to pH 7.6 and filtered for color determinations.

The curves of Figure 4 show that

TABLE I.—Chlorine Loss Resulting from Chlorination of a Rag Cooking Liquor Waste in an Open System

− Log Luminance	Chlorine Added		Chlorine Loss		pH[1]	
	Open System (p.p.m.)	Closed System (p.p.m.)	To Atmosphere (p.p.m.)	On Basis of Closed System (%)	Open System	Closed System
0.130	10,000	8,000	2,000	25.0	7.6	6.8
0.090	20,000	12,500	7,500	60.0	3.9	3.4
0.047	40,000	23,000	17,000	73.9	2.7	2.5

[1] At 5 hr.

the superchlorination in an open system resulted in an appreciable loss of chlorine to the atmosphere. The degree of chlorine loss is shown effectively by Table I. The chlorine losses, varying from 25 to about 74 per cent, increased with increasing additions of chlorine and decreasing pH values.

Contact Time Required for Color Reduction by Chlorination

When chlorination is in the acid region below pH 3, the color reduction of wastes, such as rag cooking liquor, yeast, and gum, is practically instantaneous. The time required is so short that it is difficult to obtain luminance data showing the rate of color reduction. This indicates that the "free chlorine" reaction is very rapid. However, it has been noticed that the rate of color reduction obtained when chlorination is in the vicinity of pH 7.0 is somewhat slower. To determine the actual time required for color reduction at 20° C. and pH 7.0, aliquots of rag cooking liquor and gum waste effluents from an activated sludge system were adjusted to pH 7.0 and chlorinated (NaOCl) to various degrees. Luminance values were determined on unfiltered samples of each aliquot at selected time intervals.

The results obtained (Figure 5) for the rag liquor waste show that the chlorination reactions were at least 60 per cent complete within 5 min., and at least 95 per cent complete within

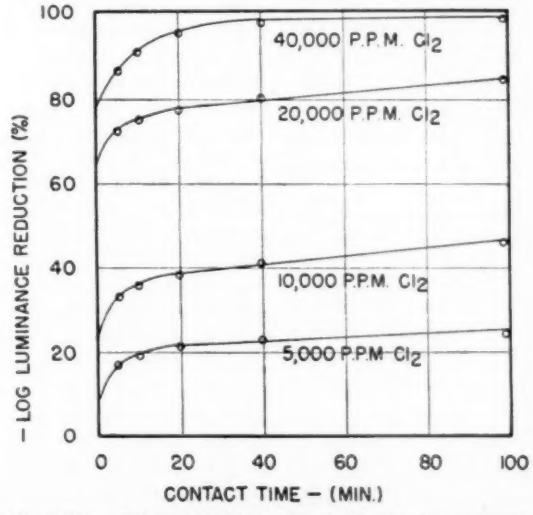

FIGURE 5.—Color reduction rate of chlorinated rag waste.

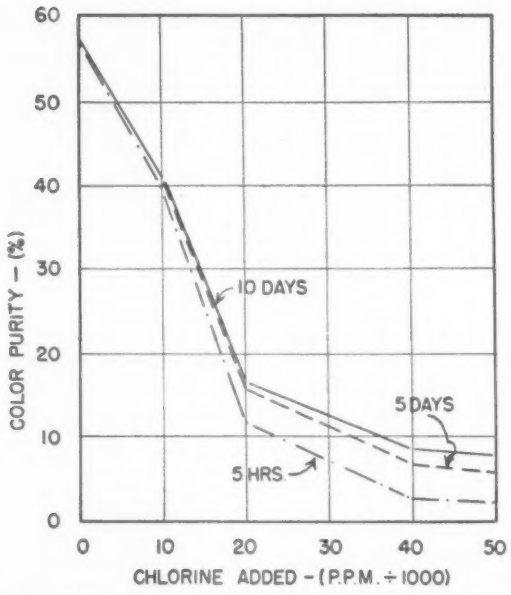

FIGURE 6.—Color stability of chlorinated rag waste.

100 min. The gum waste color reduction curves followed a similar rate pattern. From the practical standpoint, these data may be of value when contact basins for color reduction treatment of industrial wastes are designed.

Color Stability of Chlorinated Wastes

Chlorination effectively reduces the color of various industrial wastes, but the question arises as to how stable the color characteristics of chlorinated industrial wastes are with respect to time. To study this effect, aliquots of raw rag cooking liquor and raw gum wastes were chlorinated (NaOCl) at 20° C. and pH 7.0. After selected time intervals (0 to 10 days), all samples were adjusted to pH 7.6 and filtered for color determinations.

TABLE II.—Color Stability of Chlorinated Raw Rag Cooking Liquor and Gum Wastes

No.	Chlorine Added (p.p.m.)	10-Day Color Return[1]	
		Rag	Gum
1	10,000	8.8	—
2	15,000	12.7	—
3	20,000	11.0	—
4	1,000	—	5.7
5	2,000	—	7.3
6	3,000	—	6.8

[1] As per cent of color return.

Some results on rag liquor color purity (Figure 6) show that slight color returned over a 10-day period. The maximum color return took place in the region above 20,000 p.p.m. chlorine added. For 20,000 p.p.m. chlorine added, approximately 11 per cent of the color removed had returned within 10 days. There was also a slight color return with the gum waste over the 10-day period. At 3,000 p.p.m. chlorine added, approximately 6.8 per cent of the gum waste color removed had returned within 10 days. With both wastes (rag and gum) the quantity of color return increased with increasing color reduction. However, the color return determined as percentage of the color removed was approximately the same, as shown by Table II, which indicates that the color reduction was a result of chemical sub-

stitution or addition and not necessarily a breakdown of a complex structure.

Effect of Chlorination with Varying Waste Concentration

Industrial wastes may vary considerably in the concentration of colored matter. Therefore, the feasibility of projecting color chlorine requirements from a given concentration of a waste to varying concentrations of the same waste was investigated. The question is, will the efficiency of chlorine color reduction be the same regardless of the waste concentration?

Samples of gum and rag cooking liquor wastes from an activated sludge process were diluted to various degrees with distilled water and adjusted to pH 7.0 for chlorination. The same quantity of chlorine (NaOCl) was added to each diluted sample to determine the effect of dilution on the degree of color reduction. Sufficient chlorine was added to cause an approximate − log luminance reduction of 50 per cent. Following a 4-hr. contact period all samples were adjusted to pH 7.6 and filtered for color determinations.

The summarized results (Table III) show that the degree of color reduction was approximately the same regardless of the dilution. This may not be the rule with all concentrations of such wastes, since the solubility of HOCl will be influenced by the concentration of soluble material present. Where large quantities of soluble material effect losses of volatile HOCl, subsequent chlorination efficiency is reduced.

TABLE III.—Effect of Chlorination on Color Characteristics of Gum and Rag Cooking Liquor at Various Waste Concentrations

Waste	Rel. Vol. of Conc. Waste Present (ml.)	Chlorine Added (p.p.m.)[1]	− Log Luminance Reduction (%)
Gum	8.40	1,500	45.1
Gum	5.04	1,500	47.3
Gum	3.36	1,500	47.6
Gum	1.68	1,500	44.6
Rag liquor	2.75	10,000	39.6
Rag liquor	1.65	10,000	41.8
Rag liquor	1.10	10,000	40.9
Rag liquor	0.55	10,000	39.1

[1] On basis of concentrated waste.

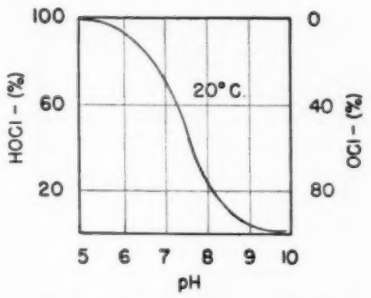

FIGURE 7.—Relative amounts of HOCl and OCl^- at various pH values.

Chlorination at Varying pH Values

The form of chlorine in a water solution varies with the pH of the solution and the concentration of chlorine present. The hydrolysis of chlorine in a water solution takes place in the following manner:

$$Cl_2 + H_2O \rightleftharpoons HOCl + HCl$$
$$\uparrow\!\!\downarrow \quad H + OCl^-$$

Chang (1) calculated values for the ratio of Cl_2/HOCl at various molar concentrations and at pH values from 0 to 3.0. According to these calculations, with a titratable chlorine content of 7,100 p.p.m., there is no appreciable quantity of free chlorine present until the pH is below about 3.0. Above this pH value, chlorine is available as either HOCl or OCl^-. The actual relationship is shown in Figure 7, which shows that the maximum quantities of HOCl and OCl^- are available, respectively, below pH 5 and above pH 10.

Experiments were run to determine the relative effect of chlorine on the color characteristics of industrial wastes at various pH values and to de-

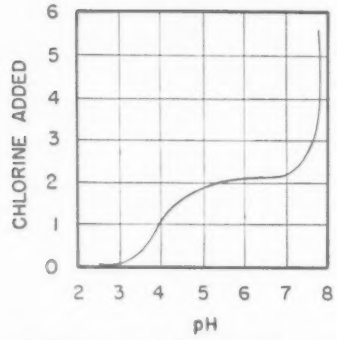

FIGURE 8.—Relative amounts of chlorine required for maximum instantaneous color reduction of an alizarin blue dye.

termine the degree of chlorine loss in open chlorination systems.

Alizarin Blue Dye Solution

A sample of a concentrated alizarin blue dye solution was diluted with distilled water, and aliquots, adjusted to pH values ranging from 2.8 to 11.0, were chlorinated to the extent necessary to give an immediate complete color removal. Chlorine water having a chlorine content of 67 p.p.m. was added.

The quantities of chlorine necessary to give 100 per cent immediate color reduction at various pH values are indicated by Figure 8. Since it is only desired to show the effect of pH on chlorine required for color reduction, the chlorine addition values are relative, but the curve shows that there is a difference in the action of chlorine at various pH values. It appears that there are three different zones, one below pH 3, one in the pH range from 5 to 7, and the last in the pH region above 7.8. The curves show that the chlorine color reduction effectiveness increased with decreasing pH, but these results cannot be used as a general rule for color reduction problems of this type, because the respective reaction rates of the various chlorine forms are not taken into consideration. Previously it was pointed out that there is a difference in the reaction rate of chlorine at high and low pH levels.

Gum Waste Activated Sludge Effluent

Samples of a gum waste activated sludge effluent (325 p.p.m. B.O.D.) were diluted at 20° C. and adjusted to various pH values ranging from 1.8 to 12.0. All aliquots were chlorinated (NaOCl) to the same extent in both open and closed systems. Following a 24-hr. contact period, all samples were adjusted to pH 7.6 for B.O.D. (dilution and direct 5-day 20° C.), and color determinations made on filtered samples.

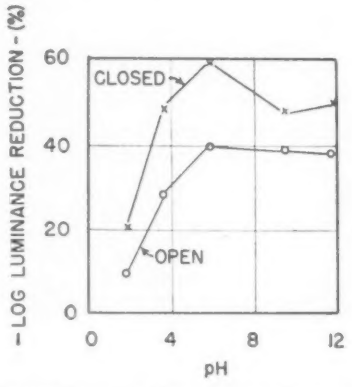

FIGURE 9.—Effect of chlorination in open and closed systems, at various pH values, on the – log luminance of gum waste.

Figure 9 shows that the maximum color reduction was obtained at a pH value of approximately 6.0 in both open and closed systems. Furthermore, the color reduction at pH 6.0 was 4 or more times as great as the results obtained at the various other pH values. The curves also show that there was a significant loss of chlorine in the open system. The extent of the losses may be seen from the – log luminance reduction curve (Figure 10). This curve shows the ratio of color reduction in the open systems to color reduction in the closed systems, and these values subtracted from 100 per

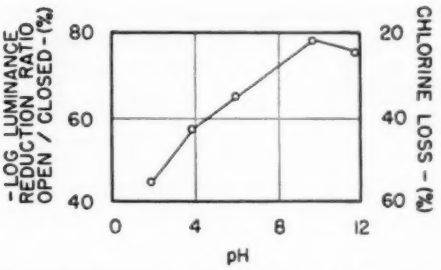

FIGURE 10.—Luminance reduction (− log) ratios of chlorinated gum waste in open and closed systems.

cent indicate the chlorine losses in the open systems. The chlorine losses were as high as 55 per cent (pH 1.8 in Figure 10). At the point of maximum color reduction, the chlorine loss to the atmosphere was approximately 35 per cent.

The direct oxygen utilization curves (Figure 11) indicate a significant difference in the oxidation rates of the chlorinated samples. At pH 5.9 there was no measurable B.O.D., and it was at this point that the maximum color reduction was realized. On the other hand, the curve for pH 12 shows an increase in B.O.D. The effect of the chlorination on the 5-day direct utilization and dilution B.O.D. values is shown in Figure 12. The dilution B.O.D. curve shows an increase in B.O.D. for the chlorinated samples at all pH values except 5.9. At the latter value the B.O.D. was 40 p.p.m., as compared with a value of 0 p.p.m. by the direct utilization method. These data show that chlorination increased the 5-day B.O.D. of the gum waste, but the chlorinated compounds were evidently slightly toxic or not readily available to biological decomposition. Gellman (2) has shown that the initial oxidation lag obtained with chlorinated rag and jute cooking liquor wastes may be appreciably reduced by using acclimatized seed. The increase in B.O.D. resulting from chlorination might possibly be explained on the basis of a breakdown of complex organic structures into relatively simple products

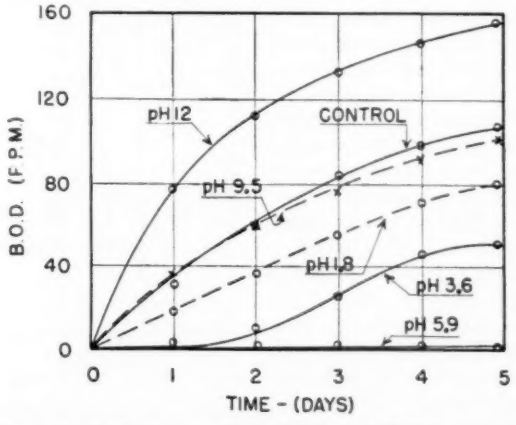

FIGURE 11.—Effect of chlorination on direct (Warburg) B.O.D. of gum waste at various pH values.

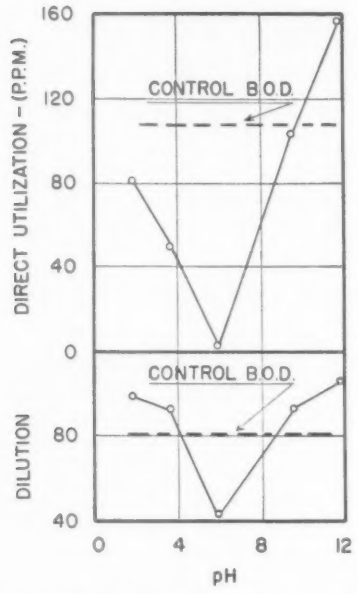

FIGURE 12.—Reduction of 5-day B.O.D. (dilution and direct) of gum waste by chlorination.

more readily available for biological oxidation.

Sulfite Cooking Liquor Waste

Samples of a sulfite cooking liquor activated sludge effluent were diluted with distilled water and adjusted to various pH values in the range from 1.8 to 12.0. All samples were chlorinated (NaOCl) to the same extent in both open and closed systems for a 24-hr. period. Following the contact period, the pH values of all samples were adjusted to 7.6 for B.O.D. (dilution and direct) determinations, and filtered for color determinations.

The effect of chlorination on the color characteristics is illustrated in Figure 13. The degree of color change was approximately the same in open as in closed systems at all pH values. Below a pH value of approximately 6 there was a considerable color increase as a result of chlorination. The maximum color reduction resulting from chlorination was obtained in the approximate pH region from 6 to 10, where the purity change was zero and the − log luminance decreased by approximately 50 per cent. At pH 12, the − log luminance was reduced by 55 per cent, but the purity had increased by 13 per cent.

The effect of chlorination on the B.O.D. of the sulfite waste liquor is shown in Figure 14. All of the chlorinated samples, except that at pH 3.5, had 5-day B.O.D. values which were lower than the control (unchlorinated) B.O.D. The sample chlorinated at pH 3.5 had a 5-day B.O.D. of 300 p.p.m., as compared with the corresponding control B.O.D. value of 203 p.p.m. After 7 days, the B.O.D. of the sample chlorinated at pH 1.8 had also increased to a value (422 p.p.m.) considerably greater than the corresponding control value (255 p.p.m.) It is possible that the increased B.O.D. values

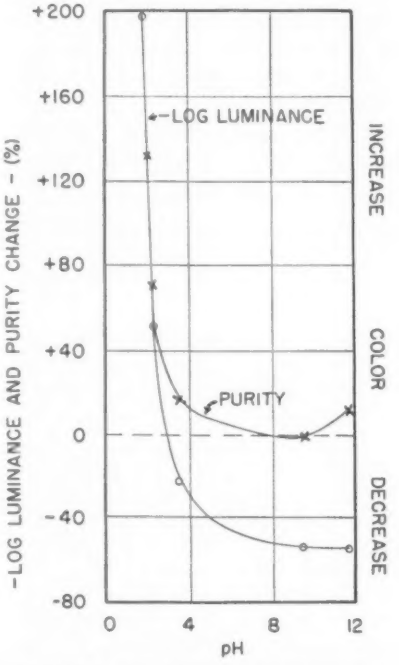

FIGURE 13.—Effect of chlorination in open and closed systems at various pH values on color of sulfite waste.

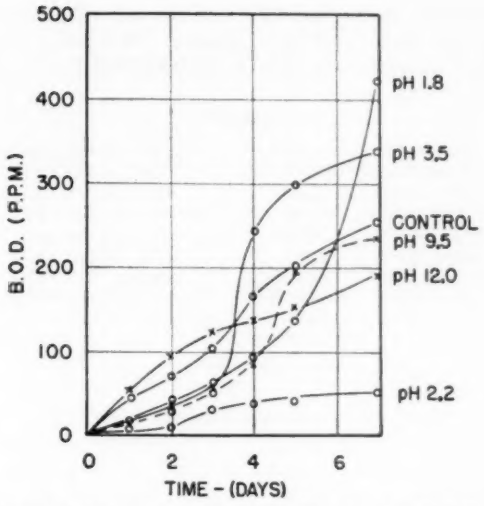

FIGURE 14.—Effect of chlorination at various pH values on B.O.D. of sulfite liquor.

resulted from a partial breakdown of the complex lignin or other organic structures. The lower 5-day B.O.D. values do not necessarily mean that the ultimate B.O.D. was reduced.

Rag Cooking Liquor and Yeast Wastes

Chlorination experiments were also conducted with raw rag cooking liquor and yeast activated sludge effluent wastes. In both cases, there were appreciable losses of chlorine to the atmosphere throughout the pH range from 1.8 to 12. The maximum color reductions were obtained at pH 9.5 for the rag liquor waste and at pH 6 for the yeast waste.

Conclusions

As a result of this study on industrial waste color reduction by chlorination, the following conclusions are drawn:

1. The quantities of chlorine required for varying degrees of industrial waste color reduction are best determined on the basis of the color characteristics of the wastes.

2. Considerable losses of chlorine to the atmosphere may be expected when industrial wastes are chlorinated for color reduction throughout the pH range from 2 to 12.

3. The effectiveness of chlorination for industrial waste color reduction varies with the form of chlorine and the pH of the waste solution.

4. A color return on the order of 5 to 15 per cent of the color removed from an industrial waste by chlorination may be expected within a 10-day holding period.

5. The rate of reaction of chlorine with industrial wastes increases with decreasing pH.

6. The effect of chlorination on the B.O.D. of an industrial waste varies with the pH of the waste, and in some cases the result may be an increase in the 5-day B.O.D.

7. In general, color reduction by superchlorination is relatively low.

Summary

Studies to determine (a) the effect of chlorination on the color and B.O.D. characteristics of industrial wastes and (b) the influence of related factors on color reduction show that the effectiveness of chlorination for industrial

waste color reduction is dependent upon the pH of the waste solution, the form of chlorine, the contact time, and the loss of chlorine to the atmosphere. As a rule, color reduction by superchlorination is relatively low.

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2. Gellman, I., "Studies on Biochemical Oxidation of Sewage, Industrial Wastes and Organic Compounds." Doctor's Thesis, Rutgers University, New Brunswick, N. J. (Jan., 1952).
3 Hanlon, W. D., "Industrial Waste Color Measurement and Its Application to Color Reduction." Master's Thesis, Rutgers University, New Brunswick, N. J. (May, 1950).

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Stream Pollution

JUDICIAL ASPECTS OF WATER QUALITY CRITERIA

By Earl C. Borgeson, Vinton W. Bacon, Richard H. Gilman, and Jack E. McKee

Respectively, Assistant Librarian, Harvard University Law Library, Cambridge, Mass.; Executive Officer, California State Water Pollution Control Board, Sacramento, Calif.; Engineer with Leeds, Hill and Jewett, Consulting Engineers, Los Angeles, Calif.; and Associate Professor of Sanitary Engineering, California Institute of Technology, Pasadena, Calif.

Many of the state and interstate agencies that administer programs of water pollution control in the United States have promulgated rigid water quality standards, often in combination with a system of stream classification or zoning. In contrast, the California legislation enacted in 1949 does not provide for fixed effluent standards, minimum degrees of treatment, or stream classification. Rather, the California program is based on the concept of case-by-case determination of whether pollution threatens or exists in any area. Discharge requirements are based upon a reasonable balance of all equities in each separate case and each case, in turn, is related to long-range plans formulated to maintain water at a quality suitable for major beneficial uses. To aid the California water pollution control boards in their case-by-case consideration of pollution problems, the State Water Pollution Control Board contracted with the California Institute of Technology to make a thorough investigation and critical evaluation of the technical and scientific literature dealing with water quality criteria for the major beneficial uses of water, such as its use for domestic and industrial water supplies, fish and other aquatic life, shellfish culture, recreation, wildlife propagation, irrigation, and stock watering. The scope of the investigation included a survey of judicial expression dealing with water quality criteria; that is, instances of water pollution litigation in which the courts have mentioned the validity, reasonableness, or applicability of technical data and standards.

The final Caltech report, printed in its entirety (abs. This Journal, **24**, 11, 1437; Nov., 1952) and distributed by the California WPC Board, represents a voluminous reference work on the subject of water quality criteria. As such, it consists primarily of detailed data relating to specific polluting substances. Inasmuch as its chapter on "Judicial Expression" is widely applicable to many phases of sanitary engineering, it has been condensed for presentation in This Journal.

Survey Source Material

In this investigation, it was necessary to turn directly to the law materials and to apply the methods of legal research. Law materials are divided into three classes: source materials, commentaries, and research materials. The source materials are those in which the law itself is recorded, law being taken to include legislative enactments; administrative decisions, rules, and regulations; and judicial decisions. The commentaries on the rules of law, as they are found in the sources, consist of treatises, legal periodicals, and monographs. It is here that the theories, background, analyses, and explanations of the law are made.

Finally, the research materials are those designed to systematize, classify, digest, and index the law. Legal encyclopedias, digests, citators, indexes, and bibliographies form the research materials. In fact, every book or article is a research aid in that it directs the reader to the source materials that are relied upon as authority for the comments being made. Each of these classes was examined exhaustively for references to case decisions—the sources for this study.

Scope of Survey

In reviewing the cases, only those that directly or indirectly ruled on water quality standards, those that indicated a need for or use of scientific data on water quality, and those that spoke of the expert witness in connection with cases of water pollution have been noted. Discussions of riparian rights under the common-law doctrines, the doctrine of prior appropriation, or a combination of theories of liability (or rights) based upon interests in real property are adequately treated in innumerable legal and non-legal publications and are not germane to this research. The survey is primarily concerned with standards of water quality as they are applied to data presented in litigation, usually by expert witnesses, and the ruling of the court, if any, as to admissibility or reasonableness. Thus, there is no concern herein with proprietary rights of the riparian owners, with the enforcement of statutory or administrative standards, with the amount or measure of damages, or with water pollution cases in general where there is no mention of standards or expert analysis of the water.

As distinguished from quantity, the quality of water, *per se*, is seldom a matter of litigation, the major exception being the enforcement of penal statutes. In fact, the quality of water is but one aspect of an action based on violation of a property or personal right, such as injury to land, injury to the person, injury to livestock, or protection from public or private nuisances. Usually, water quality is no more than one fact among many, to be proved by the evidence of experts. When the quality of water is being litigated, standards may or may not be evaluated or otherwise considered. This paper considers those cases in which the courts have taken the opportunity to comment upon the quality of water, standards, or technical data thereon, without entanglement with such other legal concepts of rights and liabilities.

Non-Scientific Standards Established by the Courts

There are several cases in which the court's opinion can be construed as an attempt to set a standard of water quality without the aid of scientific data. The earliest example is provided by the following quotation from *Lewis* v. *Stein* (1849), 16 Ala. 214, 50 Am. Dec. 177:

> "The only remaining question is whether the evidence shows that the saw-dust injures the water. The witnesses state that the filmy substance found in the water was created entirely or in part by the saw-dust; to what extent this substance impairs the sanatory qualities of the water, the witnesses do not know; one who was a physician thought it did not render the water less healthful. We, however, think that the existence of such a substance in the water is an injury to it; to say the least, it renders the water less pure, and is calculated to annoy and disgust those who have it to use for the ordinary purposes of life, and consequently must be an injury to it."

A landowner in Illinois was successful in enjoining the discharge of village sewage into a stream passing through his land in *Village of Dwight* v. *John A. Hayes* (1894), 150 Ill. 273, 37 N.E. 218, 49 Ill. A. 530, the court apparently concluding that the quality of water could be determined by anyone with normal faculties for observation.

> "That the sewage of a village of 1,600 inhabitants discharged into a small stream,

will materially pollute the water of the stream and render it unfit for domestic use, for at least a few rods below the point of discharge, is a proposition too plain, and too thoroughly verified by ordinary experience and observation, to admit of reasonable doubt."

To other courts, many cases of water pollution are obvious and need no analyses of the water's quality other than the normal senses or reactions. Thus, in *Klassen* v. *Central Kansas Cooperative Creamery Association of Hillsboro* (1946), 160 Kan. 697, 165 Pac. (2d) 601:

"Hogs and chickens do not die from drinking water unless there is something the matter with it. It is not necessary that there be a chemical analysis as to whether the water was polluted to make a case to go to the jury. There was ample evidence that the water in the stream was polluted."

Or in *Rusch* v. *Phillips Petroleum Co. et al.* (1947), 163 Kan. 11, 180 Pac. (2d) 270:

"Appellants contend there was no evidence of a chemical examination of the water in 1942. That is true. It was not imperative there should be proof of pollution by chemical analysis. . . . There was evidence the water was tasted and found to be very salty in 1942. . . ."

An opinion to the contrary of those discussed above was expressed in *Tyrrell-Combest Realty Co.* v. *Adams* (Tex. Civ.) (1927), 291 S.W. 252. Chemists testified that the salt content was 105 to 124 grains per gallon and unsatisfactory for domestic use, whereas Adams maintained that the water was good inasmuch as he and other lay witnesses used it. In its decision, the court stated:

"Whether water is contaminated with impurities, or contains ingredients rendering it hurtful, and maybe dangerous to the human system, and unfit for domestic use, if used continuously, is a matter for scientific investigation and analysis, and cannot be correctly determined other than by such scientific investigation as will disclose its elements and their effect when used for the purposes in question, or by such continued use as will demonstrate its safe and suitable adaptability to same, or the contrary."

A humorous, if non-scientific, approach is taken in *Town of Smithfield* v. *City of Raleigh* (1935), 207 No. Car. 597, 178 S.E. 144:

"Indeed, it seems that the trial judge subjected the question to 'trial by water,' because the record discloses that his Honor 'had drunk of the water, bathed in it, and suffered no ill effects.' The ancient mode of 'trial by water' was aforetime deemed efficacious in determining the guilt or innocence of witches, and by applying the practice of the ancient law the distinguished jurist has found the waters of the Neuse River not guilty."

Needless to say, the courts would prefer to have chemical analyses, scientific criteria, and other expert evidence; but in the absence thereof, judicial bodies have not hesitated to express their own yardsticks of water quality.

Adherence to Existing Scientific Criteria

Where standards or other measures of water quality are available and where they have been introduced into the testimony, the courts have been willing to utilize such data, directly or indirectly, in reaching decisions. This adherence to existing scientific criteria may be divided into three categories, as follows:

1. Adherence to unexpressed criteria; for example, when a court rules on a standard or on the data to which it is being applied, without reference to it in technical terms.
2. Adherence to expressed criteria; that is, where the court has measured data to a specific standard.
3. Indirect acceptance of a standard; that is, cases where expert data have been introduced in evidence and where they are apparently accepted as being either within or without a standard, which the reader must assume was known by the court, although it is not expressed.

Adherence to Unexpressed Criteria

In *Levi Blydenburgh* v. *George W. Miles and others* (1872), 39 Conn. 484, the plaintiff sued under a penal statute making it an offense to permit refuse from stated activities to enter waters of the state, in order to protect fish and fisheries. In holding for the plaintiff, the court stated:

"It is claimed that the declaration is defective in substance in not alleging that the refuse, which was permitted to drain into the sea, was deleterious to fish. As we interpret the statute it forbids, without qualification, the flowage or drainage of refuse materials from the kinds of business mentioned, into the waters adjacent to this state. It assumes that such substances are destructive, or at least harmful, to fish, and they must be so regarded until the contrary appears. We may concede that the word 'refuse' is somewhat vague, and that there may be some practical difficulty in determining, in some cases, precisely what was intended by it; but for the purposes of this case the presumption is that it has a sufficiently definite meaning to all persons who are familiar with the details of the business to which it relates. If in any case the question shall arise whether the material is refuse, within the meaning of the statute, it will be for the court, or jury, as the case may be, to determine it in the light of all the facts. It may happen that the substance in question will be found to be deleterious to fish, and yet not, strictly speaking, refuse."

A more recent case in the same jurisdiction treated standards for receiving waters in the same manner, but more precisely. From the statement of facts in *Frederick Lovejoy* v. *City of Norwalk* (1930), 112 Conn. 199, 152 Atl. 210, the court declares:

"The discharge of sewage into tidal waters by the defendant does not interfere with the health and growth of oysters upon the plaintiff's beds, but does introduce into those waters bacteria, known as *B. coli*, derived from human excrement. Certain intestinal diseases may be communicated through pollution of food from excrement of persons afflicted with such diseases, and it has been the policy of the State Department of Health in recent years to forbid the marketing of shellfish directly from grounds where pollution had gone beyond certain standards. Such standards are determined, not by the demonstrated presence of communicable disease under forbidden conditions, but by the consideration that the greater the degree of pollution, the greater would be the risk of communicating disease.

"In 1926, the Department discarded the standard of count in oyster samples previously used and adopted a standard of count of *B. coli* in samples, taken at certain depths and under certain conditions, from tidal waters flowing over oyster grounds. The number of *B. coli* per unit of water, regarded as permissible under this test was an arbitrary number, adopted by the Department, not as an indication of the presence of disease, but as a precautionary measure, based upon the assumption that the greater the quantity of *B. coli*, the greater would be the risk of disease. Tests made indicated that the *B. coli* count in the waters of Norwalk harbor exceeded the standard adopted as permissible, and the plaintiff was refused certificates for the harvesting of oysters direct from his Norwalk beds for the season of 1927–1928. . . .

"The facts do not establish any actual destruction or injury to the plaintiff's oysters by the deposit upon them of sewage filth or sludge, or other visible and offensive conditions, but are confined to the existence in the waters flowing over them of bacteria, invisible to the naked eye, varying greatly as to presence and numbers under different conditions, and affecting the marketability of the oysters only by the application of arbitrary standards, and then not because of ascertained presence of disease or disease-producing elements but as a precautionary health measure."

In the foregoing case, the court was willing to accept the standards of the State Department of Health without question, although the standards are not referred to in terms of specific values.

Adherence to Expressed Criteria

The second category, where criteria are expressed and data are recited, presents a greater variety in factual patterns. For example, an accepted criterion of dilution of sewage is expressly approved in *Platt Brothers and*

Co. v. *City of Waterbury* (1899), 72 Conn. 531, 45 Atl. 154, 48 L.R.A. 691:

"The accepted rule of safe tolerance is one part of sewage to twenty parts of pure water. It is found that during the months of July, August, September, and October of the years 1894, 1897, the average ratio of sewage in the waters of Naugatuck river a short distance below Platt's mills to pure river water has been substantially one part of sewage to about eleven parts of pure river water; . . . ."

Likewise, in *City of Cape Girardeau* v. *Herminia Hunze* (1926), 314 Mo. 438, 284 S.W. 471, 47 A.L.R. 25, the court states:

"Respondent's evidence also tends to show that the ratio of thirty parts of water to one part of domestic, or sanitary sewage is generally accepted by sanitary engineers as sufficient to prevent a nuisance; that ordinary sanitary sewage contains 99.8 per cent water and 0.2 per cent organic matter; that dilution with water tends to destroy sewage; that the organic matter will become attenuated, or broken up, by the process of dilution; . . . ."

Federal requirements were utilized and apparently adopted in *Horton* v. *Town of North Attleborough* (1939), 302 Mass. 137, 19 N. E. (2d) 15. Here the plaintiff sued the town for lead poisoning incurred from the water that was carried from the main to the house in lead pipes.

"This case relates to the plumbo-solvency of water, that is, the capacity of carbon dioxide, found to some extent in all natural water, to dissolve lead while water stands in or passes through lead pipe, and thus to render the water poisonous. Three tenths of a part in a million, or three parts in ten millions, is adopted by the United States Department of Health as the maximum amount of lead which may safely be in drinking water. Four parts of lead in a million make drinking water positively dangerous."

A reference to the total count of bacteria as expressed in "government regulations" is contained in *Bountiful City* v. *De Luca* (1930), 77 Utah 107, 283 Pac. 435, and this criterion is used without question by the court in stating that:

"Evidence was also given to show that samples of water were taken from the reservoir and from the creek above the intake while the goats were in the creek, and that such samples contained from 130 to 250 bacteria to the cubic centimeter, and that according to government regulations water containing more than 100 bacteria per cubic centimeter was unwholesome and injurious for culinary purposes. . . ."

A limiting value for alkalinity as expressed by an unspecified yardstick occurred in *Cushman et al.* v. *The Highland Ditch Company* (1893), 3 Colo. App. 437, 33 Pac. 344, when the court stated:

"To sustain their action, the plaintiffs showed by chemical and professional testimony, as well as by the testimony of farmers, that the waters of the lake were impure, and held (according to some of the witnesses) nearly two hundred grains of solid alkaline matter to the gallon, when thirty-five is the limit consistent with safety."

Preference of One Standard Over Another

There are no cases involving a judicial determination of the preference of one standard over another. Apparently conflicting standards have not been an issue in litigations at the appellate level to date.

Indirect Acceptance of Standards

The existence of some sort of standard or criterion is assumed to have been known by the courts in certain cases, although it is not mentioned specifically in the finding. Values of the concentration of pollutants are given, with the implication that the reader knows such values to be beyond the limits of well-defined criteria. This implied knowledge is brought out clearly in *Shell Petroleum Corp.* v. *Voss* (1942), 190 Okla. 675, 126 Pac. (2d) 540:

"He placed the salt content of the creek at only 1048 per million. It is known that

salinity of 1000 per million is negligible; and that salt only becomes harmful to vegetation when it approaches 4000 per million.

"Water that in normal flow contains only 1048 parts per million of salt is only 48 parts per million above the known negligible and unharmful state and is more than 2000 parts below the known injurious minimum level, in so far as timber, grasses, and natural vegetation are concerned. . . ."

A lower limit for the desirable dissolved oxygen content of a stream is assumed to have been known by the court in *Adam Eckart* v. *City of Belleville* (1938), 294 Ill. App. 144, 13 N.E. (2d) 641, in stating:

"The stream contained a soapy scum on the surface of the water and teemed with sludge deposits with tubifex worms, fungus growth and vile odors. About three miles south of tank No. 1 the water was in the same condition and contained little dissolved oxygen. As far as 15 or 17 miles down the stream the water was turbid with yellow scum; sludge deposits gave off vile, foul odors, and had a dissolved oxygen saturation of only 35 per cent."

In *West Penn. Water Company* v. *Sunnyhill Coal Co.* (1945), 93 Pitt Legal Jl. 541, the plaintiff sought a mandatory injunction against the defendant for polluting the water supply by strip mining of coal. Both parties had tried to solve the problem by lime treatment of the wastes, but the case eventually went to court, where the ruling was in favor of the defendant on the grounds that the water supply was permanently injured and that the plaintiff came too late for relief by injunction. In this case, criteria of pH, alkalinity, and hardness are indicated, but not expressed.

There are other cases, such as *Allis-ton* v. *Shell Petroleum Corp.* (1936), 143 Kan. 327, 55 Pac. (2d) 396; *Stamford Extract Manufacturing Co.* v. *Stamford Rolling Mills Co.* (1924), 101 Conn. 310, 125 Atl. 623; *Panther Coal Co. Inc.* v. *Looney* (1946), 185 Va. 758, 405 E. (2d) 298; *Cities Service Gas Co.* v. *Eggers* (1940), 186 Okla. 466, 98 Pac. (2d) 1114; *Champlin Refining Co.* v. *Smith* (1942), 190 Okla. 287, 123 Pac. (2d) 253; and *Allen* v. *California Water and Telephone Co.* (1946), 29 Cal. (2d) 466, 176 Pac. (2d) 8, where water analyses were involved in the testimony and when yardsticks of quality may have been implied, but no promulgated standards were involved. These cases grade gradually into those based upon expert evidence, as described hereinafter.

Coliform Bacteria as Indicators of Fecal Pollution

During the course of this survey of judicial expression, attention was drawn especially to the cases in which the courts referred to coliform organisms and their role as indicators of fecal pollution. It is apparent from the cases cited below that the courts have been willing to accept the use of coliform organisms as indicators of fecal pollution, and that the presence of sufficient numbers of coliform bacteria is deemed to be adequate evidence of contamination.

Highly significant was the affirmed ruling for the plaintiff in *People* v. *City of Los Angeles* (1948), 83 Cal. App. (2d) 627, 189 Pac. (2d) 489, 335 U. S. 852, 93 L.E. 400, 69 S.C. 80 which restrained the city from maintaining sewers without permits from the State Board of Public Health, part of which stated:

"The quality of water along the beach was not safe and suitable for bathing purposes as a result of such discharge and the bacterial count of *Escherichia coli* had exceeded 10 per cubic centimeter."

Another case with a more liberal limit was *State* ex rel. *Board of Health of the State of New Jersey* v. *Borough of Vineland* (1906), 72 N. J. Eq. 289, 65 Atl. 174, (affirmed on appeal) 72 N. J. Eq. 862, containing the statement:

"If coli are found to exist in considerable numbers the conditions are believed to be conducive to the propagation of pathogenic organisms. The coli are, in themselves,

harmless, and the number that may safely exist in water is not entirely certain, one thousand coli to the cubic centimeter is believed to disclose a dangerous condition of the water."

Hamilton v. *Madison Water Co.* (1917), 116 Me. 157, 100 Atl. 659:

". . . showed 30 colon bacilli to the ounce, while the samples taken at the mouth of Getchell Brook showed 300 to the ounce. . . . This high percentage did not of itself signify the presence of typhoid germs, but of the existence of a large quantity of sewage. Colon bacilli are normally present in the intestines while the typhoid germ is a parasite. The presence of a large quantity of colon bacilli in water indicates therefore sewage pollution, and naturally the greater the percentage the greater likelihood of the existence of the typhoid germ."

Pennsylvania Railroad Co. et al. v. *Lincoln Trust Co. Administrator* (1929), 91 Ind. App. 28, 167 N.E. 721, 170 N.E. 92:

". . . several samples of water were taken and found to contain gas formers and colon bacilli, the bacteria count being 2,700 colonies per cubic centimeter; the presence of colon bacilli indicated sewage pollution; the greater bacterial count, the greater the danger from typhoid bacilli. . . ."

Some witnesses said,

". . . water containing gas formers is suspicious, and all witnesses testifying on the subject agree that water showing a bacterial count of 2,700 per cubic centimeter is unfit for human consumption."

Safransky v. *City of Helena* (1935), 98 Mont. 456, 39 Pac. (2d) 644:

"*Bacillus coli* is in itself harmless. It is *Bacillus typhosus* that causes typhoid fever. This is found only in the excretion of human beings who are typhoid carriers. The finding of *Bacillus coli* in water analyses is an indication of some foreign substance or contamination in the water. Its presence creates a suspicion and indicates a possibility of the presence of *Bacillus typhosus*, and a warning that immediate combative action is necessary. It is very difficult to isolate the typhoid germ. Ordinarily, only three or four persons in a thousand are typhoid carriers. In open or surface water supply systems animal *Bacillus coli* is frequently present, but animal *Bacillus coli* never carries *Bacillus typhosus*."

John Wiesner, Jr. v. *City of Albany* (1928), 224 App. Div. 239, 229 N.Y.S. 622, aff'd 250 N. Y. 551, 166 N.E. 320:

"The presence of colon bacilli in water indicates contamination from human sources. Many types are harmless in the sense that they do not furnish the origin of disease. The typhoid bacilli (scientifically known as '*B. typhosus*') are the well-recognized cause of typhoid fever. While they are difficult of isolation they belong to the colon groups, and the presence of colon bacilli in water indicates that there is grave danger that the typhoid bacilli are also present; and this becomes a practical certainty when there is an outbreak of typhoid fever, not directly traceable to other sources of infection."

The foregoing cases illustrate judicial acceptance of the sanitary bacteriologists' use of coliform organisms as indicators of fecal contamination. Other similar cases, cited in the Caltech report, have been omitted from this paper.

One exception, however, occurred in *People* v. *Bowen* (1941), 376 Ill. 317, 33 N.E. (2d) 587. Here Bowen, the Director of the Department of Public Welfare of the State of Illinois, was indicted and found guilty by the trial court of palpable omission of duty for failing to take proper measures to render drinking water at a state hospital safe. As a result, an epidemic of typhoid fever resulted with much illness and many deaths. On appeal, the Supreme Court of Illinois reversed the decision and stated:

". . . the most that can be said for any of the 158 exhibits, is that it showed the water to be either positive or negative as to coli aerogenes. It appears from the record that coli aerogenes or colon bacillus may be friendly or inimical, and that the mere presence of the colon bacillus in water proves exactly nothing as far as typhoid fever is concerned. The tests seem to have been made by a method of broth fermentation, and determined nothing more than the presence or absence of some kind of colon

bacillus. It further appears that this type of bacillus is present in the air one breathes, in milk, on fruits and practically everywhere.

"It is further apparent that colon bacillus may be of the fecal or non-fecal types and that so far as typhoid is concerned, it is only the fecal type from man alone (not from animals) that can spread the disease. The typhoid bacillus could not possibly have been identified by the laboratory means used in any of these reports and none of them is of any value to the People in an attempt to prove the guilt of the defendent. . . ."

Rejection of Promulgated Standards

As described hereinbefore, there are numerous cases in which the courts have accepted without question standards or criteria of water quality as established by governmental bodies, or as introduced by expert witnesses. In only one reported case has there been a rejection of such standards. This case, however, presents a very limited fact situation, and the reference is further weakened by the court's own label of it as dictum; that is, a judicial opinion on a point other than the precise issue involved in a case. The standard involved was embodied in a city ordinance and the court did not have to treat the reasonableness of the ordinance, being able to decide the case on other grounds.

In *Hyman* v. *Dillon as chief of police of the City of Miami* (1920), 79 Fla. 673, 84 So. 666, the plaintiff, who was the manager of the Miami Water Co., argued that his arrest was illegal and that the city ordinance requiring a permit to sell water was invalid. Section 3 of the ordinance provides in part: "It shall be unlawful for any person, firm or corporation to sell, serve or supply for a consideration, any water for human consumption containing more than 300 parts per million of chlorine in the form of magnesium or sodium chlorides, or more than 250 parts per million of carbonates in the form of calcium or magnesium carbonates" and Section 4 provides in part: "It shall be unlawful for any person, firm or corporation to sell, serve or supply for a consideration, any water for human consumption containing more than 200 bacteria to 1 cubic centimeter, or which is not potable, or which (cannot) be used for human consumption without danger to human life." In holding for the plaintiff, the court stated:

"It is not within the power of a municipality in the exercise of its legislative function in behalf of the public health to declare that all water which contains a certain percentage of solid matter is unwholesome and unfit for use or such is not the hygienic fact.

"The ordinance was evidently intended to require that company to supply water containing not more than a certain percentage of solid or mineral matter, upon the theory that the water furnished at present by the company is unwholesome if it contains more solids than prescribed. The power of the municipality to require this to be done exists provided the standard set by the new ordinance in fixing a maximum of chlorine and carbon content marks the limit beyond which water becomes impure and unwholesome.

"Not to regard the insinuations in the evidence and inuendoes of counsel that the purpose of the ordinance was commercial and not hygienic, if we inquired into the reasonableness of the requirements of the ordinance it would be difficult to reconcile the specification limiting the chlorine content in the form of 'magnesium or sodium chlorides' to 300 parts per million with any other purpose than one to secure water agreeable to the taste, rather than necessary to the preservation of the public health."

Approval or Disregard of Expert Evidence

There have been a number of cases over the years in which the courts have expressed approval of expert evidence dealing with water quality, or even lamented its absence and suggested its use. Experimental data and opinions presented by qualified scientists are often held in high esteem by the courts. Examples of the courts' opinion of ex-

pert evidence, too numerous to cite in this article, are contained in the full Caltech report.

Miscellaneous

Before concluding, several miscellaneous cases deserve mention. They are concerned with methods of legal analysis and the judicial approach to aspects that probably are of interest only to the lawyer. Oklahoma, with much experience in cases of water pollution, has put into the case law an obvious, yet important, consideration. In *Shell Petroleum Corp.* v. *Kent* (1940), 187 Okla. 637, 105 Pac. (2d) 230, the plaintiff sued for depreciation in value of land and cattle by salt-water pollution of a creek. The defendant argued that the statute of limitation had run as the stream had been permanently polluted longer than the period established thereby. In affirming the verdict for the plaintiff, the court stated:

"To deny that a stream once regarded as permanently polluted can thereafter become relatively pure is to disregard the operation of natural forces."

Significant also is the California decision in *Wright* v. *Best* (1942), 19 Cal. (2d) 368, 121 Pac. (2d) 702, dealing with pollution by mining debris and its effects on soil and fish. There had been an agreement to permit pollution at an annual fee, to ripen into prescriptive rights. Here the court declared:

"Moreover, quality, unlike quantity which is a measurable element, is not a subject of sale."

While not strictly relevant to this investigation of instances where the courts have ruled on the reasonableness or unreasonableness of water quality standards, two cases have turned up in the course of this survey, which may be of considerable interest to water pollution control authorities. These cases deal with administrative law and the validity of a statute creating an administrative agency. The issue is that of improper delegation of legislative authority to an administrative board. It is recognized that there are other cases dealing with the same legal principle. Inasmuch as the ones presented hereinafter deal specifically with the subject of water quality standards, they were deemed to be of interest in this investigation.

In *State* ex rel. *Martin* v. *Juneau* (1941), 238 Wis. 564, 300 N.W. 187, the court held that Chapter 144 of the stream pollution law was not invalid for indefiniteness and uncertainty on the ground that it contained no standard or guide to cover the actions of the State Board of Health and Committee on Water Pollution, since the whole purpose of the law was to prevent pollution or contamination of the waters of the state by conferring power on the administrative agencies to prescribe operating results that would achieve that purpose.

In *Texas Co.* v. *Montgomery et al.* (1947), 73 F. Supp. 527, affirmed in 332 U. S. 827, 68 S. Ct. 209, 92 Law Ed. 402, the plaintiff maintained that an order of the Louisiana Stream Control Commission, of which Montgomery was a Commissioner, concerning the disposal of oil-field brines, or the Act creating the Stream Control Commission, violated the 15th Amendment of the Federal Constitution. In dismissing the plea of the Texas Co., the court stated:

". . . Plaintiff argues that there is no plan or standard fixed in the act for the Commission's guidance and that the Commission is vested with discretion to approve or condemn as it sees fit. The obvious answer is that it would have been impossible for the Legislature to prescribe a formula for the Commission's guidance or to lay down rules and reference to harmful pollution, applicable to all water: what might be harmful pollution in one body of water might not be harmful pollution in another. Of necessity, a determination of the facts of what might constitute harmful pollution was left to a fact finding group. . . . The

modern tendency is to be more liberal in permitting grants of discretion to administrative bodies or officers in order to facilitate the administration of laws as the complexity of economic and governmental conditions increases."

Summary

The case law surveyed in this study does not reveal one case in which water quality criteria have been pronounced directly as reasonable or unreasonable. Several decisions have accepted standards as satisfactory by reference to them in relation to technical data. Many indirectly approve standards that are assumed to have been introduced into evidence from the language of the court and the presence of technical data. One case, by dictum, rejected the standards of a municipal ordinance. The cases surveyed show clearly the lack of precise, step-by-step judicial development of rules for water quality standards.

It may well be that only legislative or administrative action is capable of providing an adequate solution to the problem of water quality criteria. This survey, however, cannot be said to demonstrate that the judicial process is incapable of coping with the problem. If anything, it merely demonstrates that the lawyer and his expert witnesses, in presenting a case, often fail to seek out and intelligently present scientific data. It is hoped that the Caltech study can make the data more readily available to the lawyer and expert witnesses.

THE OPERATOR'S CORNER

CONDUCTED BY HERBERT P. ORLAND

OPERATING GADGETS AT BOISE, IDAHO, PLANT

BY A. J. WAHL

Superintendent, Sewage Treatment Plant, Boise, Idaho

A simple and inexpensive device, or a seemingly inconsequential change in a plant unit, may sometimes reduce the operator's work or worry so drastically as to make one wonder how he ever got along prior to its introduction. Some of the "gadgets" made and utilized at the Boise sewage treatment plant are described herein in the hope that others may be able to adapt them to their own situations, if applicable, and benefit thereby.

By-Pass Modification

What has become one of the plant operating units by reason of its effect on plant operation, is a gate and float unit installed on the emergency by-pass. A concrete wall was constructed in front of the original headwall at the outfall end of the by-pass (Figure 1). A 3-ft. wide sluice opening extending the full depth of the wall allows flushing of the line when necessary. A wooden gate with lap joints is held in place by angle-iron guides to close the opening. An old gate stand was salvaged to permit raising or lowering of the gate as required.

Ordinarily, the gate is closed. In this position its top is 3 ft. above the top of the sewer. This is below the elevation of the top of the comminutor well. With this arrangement, if for any reason the raw sewage pumps should stop, raw sewage would be backed up in the main interceptor line until it reached the top of the gate, then overflow to the river. This would cause no damage to the comminutor or the basement where the pumps are located.

Another advantage of the overflow gate is that it eliminates deposition of silt in the by-pass line when dams upstream on the receiving stream are desilted each year. Prior to installation of the gate, this was a serious

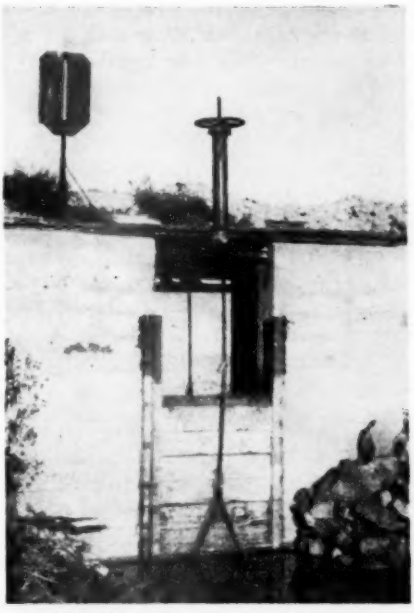

FIGURE 1.—Sluice on emergency by-pass permits additional flexibility in operation while easing operator's mind.

FIGURE 2.—Indicator on emergency by-pass float is visible from main office.

problem, on one occasion resulting in complete plugging of the line.

Still another advantage of the arrangement is that the flow of raw sewage to the plant can be evened out to some extent. This is accomplished by partially closing the comminutor gate and utilizing the interceptor and by-pass as "storage" facilities during the peak flow hours. As a safeguard against overflow of raw sewage into the receiving stream, a float and indicator (Figure 2) were installed. These are so arranged that the elevation of sewage in the by-pass is easily detectable from the main office by means of the indicator.

The arrangement has yet another concrete advantage in operation, in that it allows backing up of sewage to an elevation slightly in excess of the pump impeller when a raw sewage pump is to be started. This eliminates the necessity for priming or vacuum during the pump starting procedure.

A small quantity of raw sewage lies in the 130-ft. long emergency by-pass line. Normal daily use surges help to exchange some of the sewage in the dead line. The line is flushed out occasionally during high water.

Total cost of the gate installation and appurtenances was less than $90, including the cost of 2 cu. yd. of concrete, form lumber, gate materials, and float and indicator materials. Labor was performed by plant personnel.

Sand Tools

Fine sand in the sewage flow presents a problem by settling out in the primary clarifier influent channels. To determine the depth of the deposited sand, the sounding device at the left of Figure 3 is used. The sounder consists of ½-in. tubing, to which is welded the top of a 5-gal. paint can, and in which is inserted a ¼-in. rod. In use, the disc settles on top of the sand, but

FIGURE 3.—Sand depth sounder (left) and sand scraper (right) for cleaning primary clarifier influent channels.

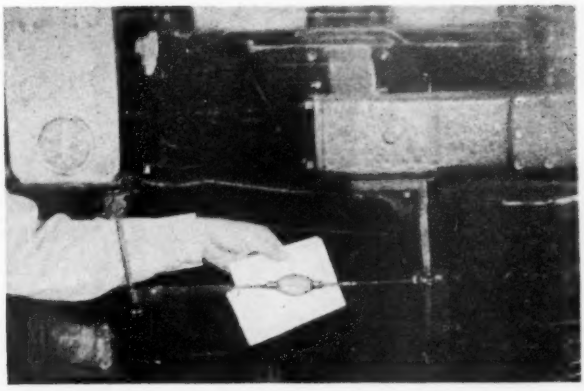

FIGURE 4.—Simple throttle yoke holds gas engine speed constant despite vibration.

the rod settles to the channel bottom. Suitable markings at the upper end of the rod give the sand depth.

To remove the sand, the scraper at the right of Figure 3 is used. This consists of a coop pan mounted by a swivel yoke on the end of a long rod. Sand can be removed from the primary influent channel with this device without interrupting the flow through the channel.

Engine Speed Control

The sludge gas engines driving the rotary air blowers at the Boise plant are set on a spring base. The slight vibration resulting from operation under these conditions continually shifted the throttles, changing the speed of the engines.

This condition was overcome by the arrangement shown in Figure 4. A slotted hook on the throttle (left) engages a wing-nutted screw on the end of a turnbuckled bar, which in turn is anchored (at the right) to an existing bracket. The slot-and-wing-nut combination at the throttle end allows the control bar to be disconnected quickly in case of necessity. The turnbuckle permits advancing or retarding the throttle, then holding it indefinitely in the set position.

Sludge Samplers

Figure 5 shows a homemade tongs for handling digester supernatant sampling containers, together with a "slide rule" arrangement for measuring sludge drawoff. When sludge is drawn to the drying beds, the tank water level drops, as observed in the overflow pipes. The slide rule measures the amount of the drop, and is graduated

FIGURE 5.—Homemade tongs make supernatant sampling easier and "slide rule" measures sludge drawoff for sale to contractor.

FIGURE 6.—Counterweight helps in opening digester overflow box lid. "Scotchlite" strip (arrow) shows position of floating cover at night.

to read directly in gallons. Analysis of the dry solids content permits calculation of the amount of sludge on a dry volume basis, on which the purchasing contractor is charged. The figure so obtained is a check against the actual haulage and agrees with that value within 5 per cent by correcting to 70 per cent moisture in the dry sludge.

FIGURE 7.—Shop-made sludge loader is powered by ½-hp. gasoline washing machine motor.

Back and Step Savers

The steel lid of the digester overflow well weighs approximately 95 lb. To reduce the possibility of back strains, a counterbalance (Figure 6) was rigged with a piece of pipe, a pulley, some cable, and some old iron.

A great saver of steps, especially at night, is a 4-in. by 16-in. piece of "Scotchlite" pasted on the floating cover near the top of the cover sidewall. Reflection of a flashlight from this strip shows the floating cover position from a distance at night.

Another back and step saver is the shop-made sludge loader shown in Figure 7. Basic materials of the loader are a Ford front axle, angle iron, galvanized iron, some belting, and some V-belt pulleys. It is powered by a ½-hp. gasoline motor from a washing ma-

chine. Total cost was less than $100. Its use saves approximately $1 per cubic yard over the cost of loading the sludge by hand into a dump truck. The loader is light and one man can easily control it in sludge beds for loading directly into dump trucks.

Acknowledgment

The pictures used herewith were taken by personnel of the Engineering Department, Idaho State Department of Public Health, who have been most helpful and cooperative in operation of the plant.

1952 OPERATORS' FORUM *

J. HENRY L. GILES, *Leader*

Assistant City Engineer, Meriden, Conn.

Chairman Giles:—The subject of aerobic treatment alone could take a whole session and more. Nevertheless, the discussion invited here is on the broad subject of aerobic treatment, including trickling filters, applications, rights, sand filters, activated sludge, lagooning, utilization of sewage for farming, and any other phase.

Bernard P. Skulte, Sanitary Engineer, Stone and Webster Engr., Inc., Boston, Mass.:—Irrigation with water carrying domestic wastes was known in the ancient world, for instance in Athens. In the Middle Ages, the town of Bunzlau, Silesia, was famous for its sewage irrigation facilities.

With the concentration of population and construction of sanitary sewers, the immediate pollution of rivers, lakes, and harbors was the factor which stimulated early irrigation on land. As sewage was applied on the fields of the sewage farms, owned by the communities themselves, attempts at economy of installation and operation usually resulted in too much sewage being used on too little land. Septic conditions were apt to result. Three factors retarded the utilization of sewage on land. The first of these was the intention of using mechanical means in sewage treatment, with its immense investments. The second was the introduction of temporarily convenient commercial fertilizers. The third was the mistake of overdosing the early sewage fields, so that even the farmers lost interest in irrigation with sewage.

When the loss of soil fertility all over the world became evident by the growing menace of soil erosion, and the science of agronomy had established the fact that soil fertility cannot be maintained by chemical nutrients alone, there arose a new movement for the increase of organic matter through improving (irrigation and melioration) of meadows and pastures. Grasses and manure increase the much-needed organic matter in the topsoil, as well as the fertility of farmland. As an example, in 1913 and 1914, thanks to the improved condition of meadows, the hay harvest in Germany established a record never reached since. The same years were also the record years of agricultural productivity. Then came World War I, with its collapse of agriculture. Following the war it took 12 years to reach the same level of productivity of grain, 14 years for potatoes, and 18 years for livestock. This increase did not keep pace, however,

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with the consumption of commercial fertilizers. Although their use in the period from 1913 to 1938 did increase (potassium by 2⅓-fold and nitrogen by 4-fold), the productivity of main crops had risen only 13 per cent; that is, at the same rate as the livestock units increased, or proportional to the manures which they supplied. Nevertheless, the amount of manure never was sufficient (now much less) to replace the amount of humus lost in the ordinary process of farming. Therefore, in many areas the farmers started to use more and more sewage effluent through broad irrigation on meadows, pastures, and farmland.

Both progress and retrogression have accompanied the solution of this problem in Europe. Engineers and manufacturers have been on both sides in this matter. There are good examples of utilization of municipal sewage and of treatment on land of textile, dairy, sugar, leather, and other industrial wastes, where mechanical treatment has failed. On the other hand, there also have been failures, largely due to disregarding of instructions or by-laws.

But there is a shortage of food supplies in Europe and new ways are required to increase productivity.

In Germany in the middle 1930's, sewage effluent from 20 per cent of the population dwelling in towns and cities was used for irrigation purposes. Meanwhile, only an additional 10 per cent of the population was served with biological sewage treatment plants. There are some good examples in England, France, Spain, and Italy, as well as a few failures.

What of the problem in the United States? This country is rich, and the standard of living here is the highest in the world. Yet, because of the wasteful exploitation of soil fertility, a period of financial depression, a series of droughts, and dust storms, this country has lost more than one-half of its agricultural land. According to the views of many scientists, the tendency during the period from 1910 to 1940 for the supply of farm products to rise faster than the demand may be about at an end. This is because the population might easily reach 174,000,000 persons by 1960. There no longer seems to be a lot of cropland that can easily and cheaply be put to work producing food. Therefore, an attempt must be made to increase the productivity per acre or open more high-grade irrigated land.

Since many of the existing sewage treatment plants are overloaded or inadequate, instead of squandering new billions for the destruction of organic matter, a more progressive approach would be to investigate the possibilties of agricultural utilization of sewage in each case. Sewage disposal on land is the most natural and the best method of sewage treatment—even better than artificial biological purification. For watercourses it affords good protection against sewage pollution. It also supplies the necessary nutrients, humus, and moisture to the soil, thus fulfilling the requirements of cultivated plants.

Any kind of arable soil will carry the light water loads imposed, but the best results will be given by light gravelly and loamy soils, used as meadows and pastures.

There is a strong argument for using only meadows and cattle fodder fields for irrigation purposes. Health officials look with some criticism on the utilization of sewage for agricultural purposes, for fear of disease. Actually, where this new method of sewage irrigation has been used successfully during the last few decades, no epidemics or even isolated cases of disease have been traced to sewage utilization. If sewage effluents are applied by overhead irrigation during the growth of grass or clover, such application should be stopped 10 days before harvest or pasturage of grass for cattle fodder. As imperative as is the use of manures, so must be the utilization of domestic sewage. Sewage is better than manure, because it comes from the better food used. What is taken

from the land must be returned to it. Only hyperaesthetes, perhaps, would protest, but the average citizen will accept the necessity for the practice as self-evident, because on it depends our survival, as well as the future of our Western civilization.

W. N. Wells, Superintendent, Sewage Treatment Plant, San Antonio, Tex.:—Although San Antonio has quite an extensive irrigation system, it wasn't particularly planned. Despite the fact that the original installation was for irrigation, additional facilities have had to be constructed in later years. The old canals are still used, however, as well as an artificial lake that serves as a storage reservoir.

That part of the San Antonio sewage flow that cannot be treated at the municipal plant is "lagooned" in Mitchell Lake. Water from this oxidation pond is used to irrigate about 4,000 acres of pasturelands. Use of the water for irrigation of vegetables is frowned on, however.

As far as sludge is concerned, the conditions at San Antonio result in some peculiar contracts. Competitive bids are taken for sludge removal. Under the present contract, the contractor pays the city $50,000 per year and sells the sludge after flash drying and grinding.

C. E. Keefer, Deputy Sewerage Engineer, Bur. of Sewers, Baltimore, Md.: —Use of the effluent from Baltimore's Back River sewage treatment plant by the Sparrows Point plant of Bethlehem Steel Co. has been adequately described elsewhere (see *Sewage Works Jour.*, **20**, 1, 15; Jan., 1948). The steel company built an effluent treatment works consisting of sedimentation tanks and chlorination facilities. Treatment consisted of adding about 5 grains of alum per gallon to the humus tank effluent. It has not been necessary to treat the activated sludge effluent used, except for chlorination.

Modifications in the humus tanks during the past two years make it possible to provide an effluent containing about 10 to 15 p.p.m. of suspended solids. Currently, therefore, the steel company does not have to coagulate the solids with alum, but simply to chlorinate.

In the early 1940's, about 25 m.g.d. of effluent were so used. In 1952, the quantity is somewhere between 45 and 50 m.g.d., with some peaks as high as 62 m.g.d. The return to the city amounts to some $20,000 to $25,000 per year. There is talk of utilizing the entire flow from the sewage plant by constructing a new pipe line to the steel plant, so that use can be increased to 100 m.g.d. or more.

The reclaimed effluent is used for cooling purposes in the sheet mills. High chloride contents resulting from salt-water infiltration have been reduced substantially by systematic inspection and repair of the trunk sewers, particularly along the harbor water front. Elimination of large industrial sources of chlorides also has reduced the chloride content considerably.

The steel company contract for effluent purchase specifies a maximum permissible chloride content of 250 p.p.m. In general, however, the chloride content is now in the neighborhood of 100 p.p.m.

L. H. Enslow, Editor, Water and Sewage Works Magazine, New York, N. Y.:—What are the legal aspects of this situation? There would seem to be a divided responsibility to the stream pollution authorities responsible for the Baltimore area. Who watches what when the effluent from the Bethlehem Steel plant now pollutes Back River?

Mr. Keefer:—The steel plant is on the Patapsco River, which is a much larger stream than Back River. In addition, since the chlorinated sewage effluent is used only for cooling purposes, it is almost entirely free of organisms and suspended solids. No cases are known of complaints arising from discharge of this effluent to the Patapsco River.

E. Sherman Chase, Consulting Engineer, Metcalf and Eddy, Boston, Mass.:—What happens when there is a steel strike or some other shutdown of the steel mill?

Mr. Keefer:—In that event, the steel mill treatment plant is shut down and the sewage plant effluent is discharged to Back River through the regular plant outfall. During the steel strike in the spring of 1952, the plant was operated for a short period each day in anticipation of putting it quickly into service again upon settlement of the strike.

Grover L. Morris, Superintendent, Sewage Treatment Plants, Oklahoma City, Okla.:—How does the city go about controlling discharges to the sewer system, especially as regards wastes high in chloride content?

Mr. Keefer:—There has not been too much of a problem with reference to industrial wastes. Whenever a new firm comes into the city we insist on waste samples. If the samples show the waste to be detrimental, treatment is required or no permission is given for discharge to the sewers. An excellent example is one waste currently under consideration. A large yeast plant has been discharging its waste into a stream emptying into the harbor. Permission has been asked to divert those wastes to the municipal sewers. In all probability, pretreatment will be a necessary prerequisite to issuance of a permit.

Question from the floor:—How do you treat chloride wastes?

Mr. Keefer:—We do not remove the chlorides. Although it could be done, it would be extremely uneconomical.

A. H. Ullrich, Superintendent, Sewage Treatment Plant, Austin, Tex.:—Is the effluent used once through, or is it recirculated? How would a sewage effluent, with possibly a high nitrate or high ammonia content, react in a cooling tower? Is break point chlorination necessary to break the ammonia?

S. L. Allison, Superintendent, Sewage Treatment Plant, Corpus Christi, Tex.:—At Corpus Christi, use of sewage treatment plant effluent in a closed cooling circuit at a refinery gave trouble with slime accumulations. Chlorination at 240 lb. per day was indicated by tests, but after the first day's operation it was found that 50 lb. per day would keep the slimes within acceptable limits. Operation was continued for some time under this dosage, but a change in pH finally caused trouble.

The slime accumulated, but oxidation in a cooling tower took care of humus accumulation. Chlorination at the rate of 57 lb. per day then entirely reduced the slimes in the closed-circuit cooling system. Effluent use is confined to make-up water in the closed system, amounting to about 65 m.g. per month. The effluent contains 10 to 15 p.p.m. B.O.D. and has a chlorine demand of about 7 p.p.m.

Chairman Giles:—There are many cases where stream and harbor flows used for industrial cooling have presented similar problems with build-up of growths. In most cases, chlorination has controlled the growths. There are also many cases where secondary treatment, such as in high-rate trickling filters, gives a better liquid to work with than some of the receiving streams used for industrial purposes.

This brings up the question of how high a rate of sewage flow is being handled by high-rate trickling filters. There is one plant in Connecticut where the maximum flow rates approximate 26 m.g.d. per acre, with a very good effluent.

Mr. Morris:—The discussion of chlorides rather amuses me, as the chloride levels mentioned strike me as being just about right. At Oklahoma City, during summer flows the chloride content of the river to which the plant effluent is discharged runs about twice that of sea water. In addition, the city is intercombed with old steel blow and salt-water lines, which are continually breaking and leaking, with resulting seepage to the sewers. Some days as

much as 1,500 to 2,000 bbl. of crude oil are received at the sewage treatment plant with the sewage, besides high chloride contents.

Mr. Chase:—Are the filter flies under control?

Mr. Morris:—The larger of the two Oklahoma City plants is the South Side plant, handling 25 m.g.d. Treatment consists of two-stage filtration with intermediate clarification and separate sludge digestion.

There are great numbers of larvae in the filters, but no free flies about the plant or structure. Some must get out, of course, but they are not in evidence about the plant. The filter walls are continually wetted down, which probably accounts for the low emergence rate. The number of snails in the filters is, however, quite high.

The primary and secondary filters are similar in construction, all being 6 ft. deep. Loadings amount to 4,300 lb. B.O.D. per acre per day on the primaries and 400 lb. B.O.D. per acre per day on the secondaries.

H. J. Graeser, Asst. Superintendent, Water Dept., Dallas, Tex.:—The trickling filters at Dallas are of standard type, 8 ft. in depth, and currently loaded at 8,000 lb. B.O.D. per acre per day. Excellent results are being obtained.

At the new plant, now under construction, the piping and orifices have been designed to handle any loading that may be found possible in later plant operation.

Chairman Giles:—It would seem desirable to determine the loading limits for filters. They seem to be able to handle considerable overloads beyond the usual design capacities, and with remarkably good results.

In one Connecticut plant, installation of a recirculation pump with an existing standard high-rate trickling filter has made it possible to maintain high flow rates all during the night, thus keeping the filter growth at an optimum and producing a high degree of purification.

Mr. Keefer:—For many years the filters at the Baltimore Back River plant were dosed at a rate of about 2.5 m.g.d. per acre. Experiments with two small rotary distributors showed, however, that flows as high as 30 m.g.d. per acre could be handled satisfactorily. As a result, the 30 acres of filters have been fitted with 50 rotary distributors, the spray pattern being superimposed on that of the fixed nozzles. At present, of course, the hydraulic loading is not too high, being less than 3 m.g.d. per acre. The rotary distributors are normally in use, the fixed nozzles being held as a reserve dosing system. The system at times has handled more than 200 m.g.d. on the 30 acres of filter area, although no recirculation is practiced. We do not consider these filters as being in the high-rate classification.

The stone in these old standard filters is a trap rock of 2½- to 3-in. size. During the 41 years they have been in operation not a single yard of replacement stone has been needed. The stone depth is 8.5 ft.

Mr. Enslow:—What about flies and odors?

Mr. Keefer:—There is no particular problem with flies. For the past two years the influent to the filters has been treated with Gammexane on a bi-weekly schedule.

It is difficult to judge, of course, but the odors seem to be no worse, and probably better, than they were some years ago. The reduced intensity of the odors may be caused by fresher sewage being received at the plant because of the greater flow now prevailing. Reduction of septicity in the sewage has improved operation of the entire plant, insofar as emanation of odors is concerned.

Mr. Chase:—What has been the effect on comparative nitrification?

Mr. Keefer:—Experiments indicate that in winter the efficiency of the filters is reduced, but that in summer, even with rates well above 20 m.g.d. per acre, removals are quite high.

Comparative nitrification drops off, as would be expected, with the higher rates of flow.

Question from the floor:—Has clogging presented any problem?

Mr. Keefer:—These particular filters have been practically free of clogging all during their 41-year history.

Sludge Digestion and Disposal

Chairman Giles:—Although sludge digestion and sludge disposal were originally listed as separate discussion topics for this session, the two are so closely connected that they might really be considered two phases of the same subject. Some of the problems involved include cleaning of digesters, starting of digesters, scum, and how to finally dispose of the accumulated sludge.

Edwin A. Locke, Operator, Sewage Treatment Plant, Hartford, Conn.:—The four digesters at Hartford are 50 ft. in diameter and about 30 ft. deep. They have been in operation about 12 years. In the spring of 1952, however, it was found necessary to clean the heating coils, as increasing difficulty had been experienced in heating the tank contents.

This particular plant has an annual shutdown period of about two months during the high river levels of the spring freshet. During this period the tanks were emptied by removing as much of the contents as posible by pumping, then purging the tank by refilling with water, removing the manhole covers, and again dewatering. About one-third of each tank was still filled with silty sludge that couldn't be moved without pressure hosing. The tank was finally cleaned, however, right down to the bottom of the cone.

Then there arose the problem of cleaning the sludge from the heating coils. Oddly enough, the sludge was not at all difficult to remove. The greatest accumulation seemed to be through the center section of the tank, but it was not a hard incrustation. Hot water was circulated through the coils to dry out the residue, after which it could be scraped or knocked off.

Cleaning of the first tank took considerable time, using rented scaffolding. With the second, however, the scaffolding was discarded. The men found that they could climb the heating coils, which are about 18 in. from the tank wall, and knock off the scale and sludge. It took 3 or 4 days to empty a tank, but half a dozen men could remove all the scale from the heating coils in about 6 hr.

In emptying the first tank, the sludge was filtered. Thereafter the tank contents were simply transferred to a cleaned tank so that plenty of seed would be available to start the digesters again. As a result, no difficulty was encountered in resuming operation because of sluggish digesters.

Of course, heat transfer was increased considerably. Prior to the cleaning operation the heat loss was only 4° or 5° F. In winter the water was pumped into the coils at 155° to 160° F. When operation was resumed the heat loss rose to 14°, although the entering water was only 120° to 122° F. Normal operation currently indicates 8° to 10° loss, with no trouble in heating the tanks, good digestion, and plenty of gas.

Chairman Giles:—Has there been any appreciable increase in gas production as compared with production prior to the cleaning program?

Mr. Locke:—Gas production now runs about 200,000 cu. ft. per day, compared with about 150,000 cu. ft. per day previously. The principal change is in better digestion; that is, better supernatant and better quality of digested sludge.

Question from the floor:—Was there much corrosion of the heating coils?

Mr. Locke:—There was very little corrosion. The coils are supported on vertical angles by U-bolts, all of ⅝-in. steel. No more than half a dozen of the U-bolts showed any corrosion, and

then it would be the U-bolt, not the pipe. The heating coils are of 2½-in. diameter wrought-iron pipe in three sections, so that heat can be applied to the upper, middle, or lower section at will.

There was one broken support on a 4-in. gas line within the tank. There was some indication, however, that the support rod had been bent and weakened during its original installation. Replacement of this support was the only repair needed. No corrosion was evident on the steel within the tank.

Some settlement of the bottom cones had taken place. The point of differential settlement seemed well-defined at an expansion joint about 6 or 8 ft. in from the wall, the settlement in some cases being as much as 1½ in. When one of the tanks was refilled, a serious leak developed, apparently because of a broken copper waterstop. The leak stopped within a few days, however, when raw sludge solids plugged the opening.

In the tanks described, there is a pipe around the inner circumference at the bottom of the side wall, with ½-in. nozzles spaced about 4 ft. apart. It was originally intended to loosen sludge in the cone by applying wash water through the jets, but earlier tryouts had shown no apparent benefits. After cleaning out the compacted sludge, however, further tests showed that the jets actually moved the sludge down the cone to at least some degree. An attempt is to be made to increase the effective tank capacity by preventing a build-up of heavy sludge through use of the jets every week or two.

Chairman Giles:—How thick was the scum blanket?

Mr. Locke:—The Hartford plant receives a lot of oil in the sewage, of both cutting and mineral types. That always is manifested by a digester scum blanket 2 or 3 ft. thick. During the period when digester heating was difficult, particularly in winter weather, the scum or floating sludge blanket might be as thick as 6 or 8 ft. If, however, longer digestion periods could be arranged (as when the plant was shut down for a few days) the scum would break up. The vacuum filter cake would then be oily and contain sticks, leaves, and bits of rags.

Mr. Allison:—At Corpus Christi we found that the reinforcing steel in the digester became cathoded and the heating coils anoded. Replacement of the heating coils with cast-iron pipe had no effect. Heating coils would be a complete loss in 8 months; the mechanism failed by electrolytic corrosion in 14 months. The estimated weight loss by this action, caused by fluorides, was in the order of 136 to 140 lb. per month.

Installation of some anodes, on cypress brackets and supplied with current by a homemade battery and charger rig, prolonged the life of replacement equipment to 9 years.

As regards sludge disposal, I feel that we are wasting sludge. Chemical soil conditioners designed to hold the soil and soil moisture are being marketed. But sludge will accomplish the same purpose, opening the soil to allow water penetration.

We have developed another type of sludge, called "acidized." It is packaged in used flour bags, costing 4¢ each, and is sold for $1 per bag. Before sacking, sulfate is added at the rate of 15 lb. per cubic yard. This product has been used most successfully in restoring lawns and lasts about 2 years when properly applied. Quite a local market has been built up for this bagged product.

A. L. Genter, Consulting Engineer, Baltimore, Md.:—Digestion operations at the new San Francisco Southeast plant are progressing satisfactorily. Two of the primary digesters are filled and the solids content of the third is being built up. In addition, supernatant from the primary digesters, after elutriation, is being admitted to the secondary digester. The excellent progress of this operation resulted from being able to control the flow of raw sludge from the north plant. There

has been no evidence of acid condition, foaming, or other deleterious effects.

This is in sharp contrast to initial digester operation experience at the Richmond-Sunset plant, where intensive liming was required before equilibrium was established in the digesters.

Ralph A. Hoot, Superintendent, Sewage Disposal Plants, Philadelphia, Pa.:—Some of the Philadelphia digesters were started last winter, with extremely poor results. In the first place, the digesters were started before the sludge heaters were ready. The result was poor gasification and an extremely high carbon dioxide content in the little gas produced.

One trick we learned at Philadelphia was to seed a new digester by "cross-circulating" with an Imhoff tank. In this way it took only a matter of a few days to develop rapid gasification. Determination of the CO_2 trend in the gas gives ample warning of unbalance in the digesters.

The original digesters—those that had gotten a poor start last winter—were finally shut down and cleaned out. Restarting them with supplementary heat proved satisfactory, but some difficulty was experienced in getting the local gas utility to cooperate.

The new type of heaters (submerged combustion type) have not been in use at this plant long enough to give a full report on them. After 6 weeks of operation, however, they appear to be performing quite successfully. A matter of prime importance, however, will be that of getting the sludge to the heaters in clean condition. The troubles now experienced come mostly from grit carryover and collection of rags inside the heaters, rather than from the heaters themselves.

Chairman Giles:—What is the optimum temperature for digester operation?

G. A. Parkes, Superintendent, Hyperion Sewage Treatment Plant, Los Angeles, Calif.:—There are many temperatures at which a digester may be operated. At the Hyperion plant we have not found the optimum temperature, although digesters have been operated at 80°, 85°, 90°, 95°, and 100° F. We currently have a battery of three tanks operating at 120° F. The sludge from all those digesters, as well as the gas production and other criteria, turned out to be identical. If anything, the digesters now operating at 120° F. do produce more filterable sludge, contrary to all previous findings.

Every operator or superintendent must determine the optimum temperature for his own digestion tanks. This brings up a point that should be emphasized with all design engineers—the responsibility of providing adequate heating for the digesters. In many cases the so-called optimum temperature seems to be merely the temperature that the operator is able to get with his heating facilities.

Mr. Hoot has commented on his efforts to start digesters. Actually, there are many, many ways not to initiate digestion, and to start digesters under winter conditions without heat is virtually impossible.

At the Hyperion plant we started with the assumption that the digesters must be heated. The indirect method used—live steam injection in raw sludge entering the digester—is very successful and should be investigated more completely than it has been by design engineers.

Because there was insufficient steam available at first, a portable steam boiler was rented to augment the plant facilities. Then the digesters were filled with raw sludge as rapidly as possible to realize the benefit from the mechanical mixing devices, as well as to bring the liquid level up to the point where the seed could be advantageously admitted. To bring a digester up to temperature when full took 2 or 3 weeks.

Incidentally, to talk about getting seed sludge from somewhere for a digestion installation of the size provided

at Hyperion is futile. There, tank wagon after tank wagon load of seed sludge was hauled in from another plant, but all we did was wet the bottom of one digester.

The initial temperature objective was 85° F. At that stage all of the digesters lagged, pH dropped rapidly, and the volatile acid content rose to as high as 6,000 p.p.m. There was a thick scum and the usual foul odors of acid digestion. In all of the digesters started in this manner the initial stage lasted for some 4 to 6 weeks. Then, suddenly, the methane percentage increased, the volatile acid content decreased, the pH increased, and within a very few days first-class alkaline digestion was in progress. Up to that point there was the expected violent foaming.

After the initial establishment of alkaline digestion there was no further trouble, as the contents of tanks already in operation could be used for heating and seeding others. And by seeding is meant starting with, possibly, 70 per cent by volume of sludge from an operating digester. Small quantities of seed sludge seem to do no good.

Liming seems to be useless in some situations. When the Hyperion tanks were in the acid stage of fermentation, we were advised to lime them heavily. In one day, however, 12 tons of quicklime were shoveled into one tank—with no detectable effect.

Proper temperature provision seems to be the really important matter in starting digesters, particularly under winter conditions.

SEWER MAINTENANCE NO LONGER NEGLECTED

The following, received from the Secretary of the California Sewage and Industrial Wastes Association, reports on that organization's action toward helping its members with their sewer maintenance problems.—Ed.

For many years the sewer maintenance men have been the "Forgotten Men" of sewage disposal. Much thought and time has been given to design engineering and plant operation but little attention has been paid to the upkeep of the collection systems and the personnel charged with this duty.

To meet this growing and critical demand for more adequate knowledge of the problem of maintaining sanitary sewers, a group of interested engineers, maintenance superintendents, and others have instituted Sewer Maintenance Sections within the California Sewage and Industrial Wastes Association. This program is geared for and aimed at the men actually engaged in this type of work, regardless of whether they are crew members or superintendents.

Meetings are held monthly, always in a different municipality or sanitary district within the area of the particular section group. This is done purposely, so that operational methods, equipment, etc., may be seen "on the job." Notes are compared, questions asked, and a full interchange of ideas is stimulated.

With the continually growing complexity of sewage and the problems concerning its effective collection, it is easy to see why the maintenance section is a vital link in the chain of sewage disposal. No longer is it a case of: "not seeing, just looking." All phases and problems are thoroughly discussed, a valuable interchange of ideas is had, and the members become more efficient workers.

In too many cases the average citizen has no real conception of the hundreds of thousands of dollars silently serving him under his feet. He can see the shiny red fire engine or the buildings

which house the governmental functions, but the vital arteries of sewage collection are "out of sight—out of mind."

These valuable and far-flung systems need intelligent maintenance, just the same as the fire engines or the city streets. With this idea in mind, a small initial group of men brought the Sewer Maintenance Section into being with the full approval of the officers and directors of the C.S.I.W.A.

Since its inception a little over a year ago, interest and membership have shown a healthy increase. At the 1952 Spring Meeting in Santa Cruz, Calif., the Maintenance Section had an even larger crowd than could be readily accommodated at the first Annual Breakfast. It is anticipated that much more space will have to be provided at the Annual Meeting in the spring of 1953.

Engineers have found that they can learn much about practical sewer design from maintenance men. Equipment manufacturers have gotten many valuable ideas as to what is needed from their particular field in the way of devices, materials, etc., by attending the various sessions and acquainting themselves with the particular problems faced every day by maintenance men.

These Sections are also interested in the welfare of the individual and a thorough study of wages and job classifications has been competently made. This will have a tendency to raise the standards and emphasize the responsibilities involved. It will give governing and administrative bodies a comprehensive picture of what is demanded for the proper maintaining of one of the communities' most valuable assets, which has hitherto been neglected or passed over all too lightly.

Section meetings afford an excellent opportunity for the teaching and repeated emphasizing of safety practices. Gas hazards and their detection, or avoidance, are taught to the men in simple, understandable terms by experts. Safe practices are demonstrated and the dangers existing in underground structures are pointed out with a clarity that never could be achieved by one individual working alone in a small community.

This program has been so successful, and such great benefit has been derived by all of those participating, that it is earnestly suggested that other areas and affiliated associations seriously consider the institution of maintenance sections.

Requests for information or data pertinent to the forming or programming of such an endeavor should be directed to the State Chairman of Maintenance Sections, who is Sydney Preen, Superintendent of Sewer Maintenance, 1601 South San Francisco St., Long Beach, Calif. Also, any correspondence regarding what is being done in other Member Associations regarding this important phase of sewage disposal will be welcomed by Mr. Preen.

TIPS AND QUIPS

Safety in Sewage Works

Under this heading, Editor L. F. Skorczeski, in a recent issue of *The Sewage Works Digest*, reminded members of the Iowa Sewage Works Association of the hazardous conditions under which they perform their daily tasks. So pertinent are his comments that they are restated here. Said Mr. Skorczeski:

"We very often hear people talk about the dangerous job that the police

and firemen have, and yet the danger in their day's work is almost negligible by comparison with what the average person comes in contact with daily in the sewage works field. Let us name a few of the most common ones; asphyxiation, gas poisoning, explosion, electrocution, drowning, cave-ins, broken limbs, and continual exposure to disease germs. Maybe it is a good thing that most of us just consider them as things that may not happen to us, or there would not be any sewage works personnel.

"All the above-mentioned dangers can be eliminated, or at least minimized, if the equipment is in good condition, if guard rails and safety screens are provided, if safety equipment is used, and if generally good and safe operation is being practiced.

"Let us all exercise more care and live longer."

Anchor Bolt and Concrete Floor Repair Compound

Quick and permanent fastening of equipment of any type to concrete by means of anchor bolts—or permanent repairing of chuck holes and breaks in concrete floors—can now be done quickly, easily, and safely with a special quick-setting cement. Known as "Por-Rok," the material is applied cold and requires only a few minutes to set up. Floor patches are ready for light traffic in 15 min. Detailed information on the product is available from the Hallemite Manufacturing Co., 2446 West 25 St., Cleveland 13, Ohio.

Cannery Waste Irrigation System

A plastic irrigation system recently installed at the Hipke Foods, Inc., cannery at Mt. Calvary, Wis., was designed not only to irrigate food crops, but also to solve the problem of disposing of the large amounts of waste water produced in canning operations.

The entire system, utilizing plastic pipe, was installed in 2 hr. by two men. Besides reportedly reduced costs over other installations, the flexibility of the plastic pipe (Figure 1) allows lateral lines to be swung from one location to another as the ground becomes satu-

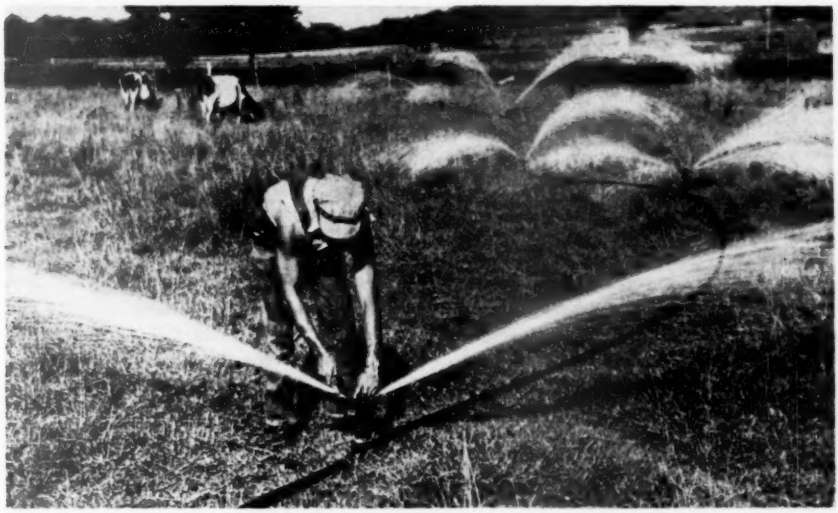

FIGURE 1.—Plastic pipe flexibility allows easy moving of laterals on spray irrigation system for cannery waste water.

rated. Resistance to soil and acid waste corrosion, as well as rot, rust, and electrolytic corrosion, is an added advantage.

The system consists of two 50-ft. mains of 3-in. plastic pipe and two 100-ft. laterals of 2-in. pipe, together with plastic tees and plugs. Six sprinklers, placed about 30 ft. apart, each handle 12 g.p.m. with a residual operating pressure of 25 p.s.i. The entire system handles about 4,300 g.p.h.

To prevent sprinklers from turning over on the pipe and tees, stakes were driven into the ground alongside the tees.

March of Mothers

From Redington Beach, Fla., comes a report that a "March of Mothers" campaign was recently started to educate the voters on the need for an adequate sewer system. The ladies set up their program on a house-to-house canvassing system designed to show each person how much he will have to pay for sewers and how inconsequential that sum is when compared to a child's health or life.

That's a powerful sales talk, and a good way of seeing that it reaches the right buyers!

Automatic Emergency Lighting Unit

In case of power failure, a new type of portable emergency unit is designed to illuminate instantly any space where extra safety measures are a "must." The unit is powered by a storage battery built into the set and maintained in readiness by an a.c. trickle charger and built-in hydrometer. Dual, sealed-beam, 100-c.p. heads provide 10 hr. of light.

Complete information on the unit is available from Central Scientific Equipment Co., 2700 W. Huntingdon St., Philadelphia 32, Pa.

Gas Sleuthing

Another myth has been exploded. In this case, however, the figurative explosion of the myth came as a result of a literal explosion of gas in a utility manhole at Champaign, Ill., in which a utility employee suffered severe burns.

As reported in a recent issue of the *Bulletin* of the American Council of Commercial Laboratories, the utility called in a local commercial laboratory to determine whether the explosive gas in the manhole had leaked in from a nearby natural gas line or whether it consisted of sewer gas from nearby sanitary sewers.

Infrared analysis was used to trap the culprit. The natural gas used in the region contains a relatively high percentage of ethane and butane, which have infrared absorptions at positions considerably different from those found in methane, the primary constituent. On the other hand, the combustible component of sewer gas is almost 100 per cent methane.

Samples of gas from the manhole were pumped through a cold trap at liquid nitrogen temperatures to condense out any hydrocarbons present. The condensate was allowed to vaporize through a drying tube into a previously evacuated gas cell. The spectrum, when compared with samples of natural gas from the gas line, showed the manhole sample to be quite different in constitution. In fact, only slight traces of hydrocarbons higher than methane were present, whereas the methane bands were very strong and no ethane was evidenced. This was considered proof that the explosive gas did not come from the utility's gas mains or from leaky service station tanks (octanes), but most likely originated in nearby sewers.

The cause of the original blow-up? A utility maintenance man lit a cigar as he entered a service manhole in the middle of town!

Reviews and Abstracts*

Effect of "Storage" on the Necessary Flow Capacity of Storm-Water Sewers in Certain Cases. *Surveyor*, **111**, 627 (Oct. 4, 1952).

When a storm-water sewer is not fed continuously along its length, it may be permissible to design the lower portion of the sewer for instantaneous rates of flow smaller than those in the upper portion. This effect results from the lapse of time required for the water to traverse the sewer's length, which in effect stores the water within the sewer. The author presents a new method of estimating how much reduction of diameter is permissible, and introduces considerations which allow greater reductions than those previously thought feasible. M. C. RAND

Proceedings of the First Southern Municipal and Industrial Waste Conference. Engineering School Bulletin No. 55, North Carolina State College. Price, $1.00 (1952).

This 170-page record covers the material presented at the Conference, which was held at North Carolina State College on March 13–14, 1952, under the joint sponsorship of that institution, Duke University, and the University of North Carolina. The following papers are included:

"Spadework for a Billion-Dollar Job of River Cleanup," by E. J. Cleary.

"History of the Development of Water Pollution Control in North Carolina," by J. M. Jarrett.

"Industry's Contribution in the Stream Improvement Program," by B. W. Dickerson.

"Municipalities' Role in Stream Pollution," by H. A. Yancey.

"Stream Pollution Control Program for North Carolina," by E. C. Hubbard.

"Industry's Stake in Water Pollution," by L. A. Danse.

"Financing and Research as Applied to Joint Municipal and Industrial Waste Treatment," by R. W. Flack.

"Municipal Sewage Works Managements' Approach to the Industrial Waste Problem," by W. M. Franklin.

"What Do You Know About Textile Wastes?" by J. A. McCarthy.

"Research in Textile Waste Problems," by R. H. Souther.

"River and Plant Relationship," by F. V. Doutt.

"Activities of the Pulp and Paper Industry in North Carolina on Stream Pollution Control," by H. W. Gehm.

"The Biochemical Oxygen Demand Test as an Indicator of Pollution," by W. B. Snow.

"By-Product Recovery from Industrial Wastes," by D. S. Arnold.

"Techniques of Research as Applied to Rendering Plant Wastes," by M. L. Granstrom.

"Textile Dye Waste Treatment," by N. L. Nemerow. H. P. ORLAND.

Treatment of Formaldehyde Wastes by Activated Sludge Methods. BY T. WALDMEYER. *Surveyor*, **111**, 445 (July 12, 1952).

The author describes laboratory and pilot plant experiments, and full-scale operating results, in the treatment of wastes containing formaldehyde and methanol, from the manufacture of synthetic resin adhesives. The raw wastes contained about 4,000 p.p.m. of total solids (7 per cent ash), and small amounts of colloidal and suspended matter, mostly starch and glue. It was calculated that the formaldehyde content was 2,000 p.p.m. and the methanol content 8,000 p.p.m. The pH ranged from 7.5 to 8.5. B.O.D. data do not appear, due presumably to the toxicity of the waste. The measure of strength

* Please send to Federation headquarters all periodicals, bulletins, special reports, etc., which might be suitable for abstracting in THIS JOURNAL. Publications of public health departments, stream pollution control agencies, research organizations, and educational institutions are particularly desired. Address such material: Federation of Sewage and Industrial Wastes Assns., 325 Illinois Bldg., Champaign, Ill.

used in these studies was "oxygen absorbed from permanganate in four hours at 26.7° C." The wastes varied in "O.A." from 500 to 20,000 p.p m., averaging 3,480 at the start of the study, in 1948, and increasing to over 5,000 in 1949.

The laboratory experiments utilized 4-in. pipes as experimental filters, and 25-l. jars as aeration tanks for activated sludge. The filter experiments are reported as "rather disappointing," and apparently were abandoned. The experiments with activated sludge showed that sludge could not be built up from the waste alone. However, activated sludge derived from sewage was capable of partially purifying the waste, provided the latter was diluted tenfold with water. It was further concluded that at least 12 hr. of aeration was necessary, although the data presented show 61.6 per cent O.A. reduction in 4 hr., 62.6 per cent in 12 hr., and 67.6 per cent in 58 hr.

The pilot plant experiments confirmed the laboratory conclusions. Once a supply of activated sludge had been built up. it remained active for two to five months, but there was practically no sludge buildup from the waste alone. The effluent contained a small amount of finely-divided floc after sedimentation, which was recovered by passing the effluent through a trickling filter.

The full-scale plant, which began operation in April, 1951, treats the waste in conjunction with sanitary sewage, derived from the plant and from 50 nearby houses. The sewage is admitted through a comminutor directly to a 5,500-gal. activated sludge aeration tank. The waste passes first to a 1-m.g. lagoon, provided primarily for equalization, since the strength of the waste fluctuates widely. The lagoon effluent is aerated and settled, to remove some of the glue by frothing. It is then diluted with condenser water and admitted to a mixing channel. where it joins the treated sewage and sludge from the sewage aeration tank. More returned sludge is added at this point. The mixture is aerated for about 15 hr., settled, and run through either of two trickling filters. A small amount of the filter effluent is recirculated to the lagoon; the remainder is diluted with condenser water and discharged without sedimentation. Waste sludge is returned to the lagoon or discharged direct to land.

Over-all purification of the lagoon effluent runs from 75 to 85 per cent on the O.A. basis. Microscopic examination of the activated sludge showed an abnormal population. Protozoa are scarce or lacking, and there are large swarms of a minute free-swimming organism. It is suggested that the latter may play an important part in the purification process.

M. C. RAND

BOOKS, REPORTS, AND PAMPHLETS

Latrobe Valley Outfall Sewer—Second Report, Bases of Design. Melbourne, Australia. 65 pp. plus 7 appendixes and 27 plates (Apr., 1952).

A report on probable future waste developments of this industrial valley east of Melbourne, Australia, prepared by Candy, Scott, and Furphy, consulting engineers of Melbourne.

Slaughterhouse and Packinghouse Wastes. By DONALD D. GOLD. Bull. No. 14, Eng. Experiment Station, Univ. of Tenn., Knoxville, Tenn. 45 pp. (May, 1951).

A comprehensive bibliography and compendium of abstracts of articles dealing with slaughterhouse wastes, packinghouse wastes, and grease recovery.

Reprints of Papers Read at the 1951 Annual Meeting. Iowa Sewage Works Association. 50 pp., mimeo. (1952).

Proceedings of 25th Annual Conference. Maryland-Delaware Water and Sewerage Association. 143 pp. (1952).

Methods of Financing Sewers and Sewage Treatment Works in West Virginia. Publ. No. 8, Bureau for Government Research, W. Va. Univ., Charleston, W. Va. 72 pp. (1952).

Methods for Treating Metal-Finishing Wastes. Ohio River Valley Water Sanitation Commission, Cincinnati, Ohio. 72 pp. Price $2.00 (1953).

Federation of Sewage and Industrial Wastes Associations

Annual Year Book
and
List of Members
1953

OFFICERS

PAST PRESIDENTS

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MEMBERSHIP SUMMARY

MEMBERSHIP LISTS

FEDERATION OF SEWAGE AND INDUSTRIAL WASTES ASSOCIATIONS

325 Illinois Building, Champaign, Ill.

1952–53 OFFICERS

President: E. Sherman Chase

Vice-President: L. J. Fontenelli

Treasurer: W. W. DeBerard

Executive Secretary-Editor: W. H. Wisely

Advisory Editor: F. W. Mohlman

PAST PRESIDENTS

Charles A. Emerson.....1928–41
*Arthur S. Bedell.....1941–42
George J. Schroepfer.....1942–43
A. M. Rawn.....1943–44
Albert E. Berry.....1944–45
John K. Hoskins.....1945–46
Francis S. Friel.....1946–47
George S. Russell.....1947–48
V. M. Ehlers.....1948–49
A. H. Niles.....1949–50
R. E. Fuhrman.....1950–51
Earnest Boyce.....1951–52

HONORS AND AWARDS

Honorary Members

The qualifications for Honorary membership in the Federation are set forth in Article II, Section 4 of the By-laws. Honorary Members are elected upon recommendation by a committee comprising the President and four latest Past Presidents, the senior Past President as chairman, in accordance with a policy adopted by the Board of Control on October 23, 1943. Honorary Members elected to date are as follows:

Charles Alvin Emerson.....1941
*Arthur S. Bedell.....1942
Julius W. Bugbee.....1942
Langdon Pearse.....1942
Charles Gilman Hyde.....1943
Howard Eugene Moses.....1943
Floyd William Mohlman.....1944
Willem Rudolfs.....1945
William John Orchard.....1946
F. Wellington Gilcreas.....1948
Wilford Willis DeBerard.....1950

The Harrison Prescott Eddy Medal

The Harrison Prescott Eddy Medal is awarded annually to a member of any Member Association of the Federation for outstanding research contributing in important degree to the existing knowledge of the fundamental principles or processes of sewage treatment, as comprehensively described and published during any stated year in SEWAGE AND INDUSTRIAL WASTES. The award commemorates Harrison Prescott Eddy, a famous engineer and a pioneer in the art of sewage treatment.

Past recipients of the award are:

Harry Willard Gehm.....1943
John Raymond Snell.....1944
Lloyd R. Setter.....1945
H. Heukelekian.....1946
Richard Pomeroy and Fred D. Bowlus.1947
F. W. Kittrell and O. W. Kochtitzky, Jr.....1948
John W. Hood.....1949
Daniel A. Okun.....1950
Peter S. S. Dawson and Samuel H. Jenkins.....1951
George S. Benton, John C. Geyer, Wen-Hsiung Li, and Knut K. Sorteberg..1952

* Deceased.

The George Bradley Gascoigne Medal

The George Bradley Gascoigne Medal is awarded annually to a member of any Member Association of the Federation for outstanding contribution to the art of sewage treatment works operation through the successful solution of important and complicated operational problems, as comprehensively described and published during any stated year in SEWAGE AND INDUSTRIAL WASTES. This award is in memory of George Bradley Gascoigne, a prominent consultant from 1922 to 1940, who demonstrated an unusual interest in matters of sewage works operation.

Past recipients of this award are:

Kerwin L. Mick.....1943
James T. Lynch and Uhl T. Mann....1944
John D. McDonald.....1945
LeRoy Winfield Van Kleeck.....1946
Leon S. Kraus.....1947
David P. Backmeyer.....1948
Wilbur N. Torpey.....1949
Clarence E. Keefer.....1950
Leonard S. Hillis.....1951
Walter Asa Sperry.....1952

The Charles Alvin Emerson Medal

The Charles Alvin Emerson Medal is awarded annually to a member of any Member Association of the Federation "for outstanding service in the sewerage and sewage treatment works field, as related particularly to the problems and activities of the Federation of Sewage and Industrial Wastes Associations in such terms as the stimulation of membership, improving standards of operational accomplishments, fostering fundamental research, etc." This award honors Charles Alvin Emerson, who served as President of the Federation from 1928 to 1941 and holds the distinction of being its first Honorary Member.

Past recipients are:

Floyd William Mohlman.....1943
Willem Rudolfs.....1944
Harold Warner Streeter.....1945
F. Wellington Gilcreas.....1946
Langdon Pearse.....1947
LeRoy Winfield Van Kleeck.....1948
William J. Orchard.....1949
Morris M. Cohn.....1950
Howard Eugene Moses.....1951
Frank Woodbury Jones.....1952

The Industrial Wastes Medal

The Industrial Wastes Medal was established in 1949 to be awarded annually in the form of a plaque for the most outstanding contribution by an industrial employee on any aspect of industrial wastes control, as published in SEWAGE AND INDUSTRIAL WASTES during the year preceding the award.

Past recipients are:

Roy F. Weston, Robert G. Merman and Joseph G. DeMann.....1950
Bruce W. Dickerson.....1951
Robert J. Austin, Roy N. Giles, C. T. Nicholson, and F. W. Scheineman.....1952

The Kenneth Allen Award

From 1943 through 1948, meritorious personal service to the Member Associations of the Federation was recognized by the Kenneth Allen Award. The award was retired in 1948.

Recipients of this award have been:

1943

Harry Thornton Calvert (ISP)
Edward F. Eldridge (Mich.)
John Kurtz Hoskins (Fed.)
Fred Merryfield (Pac. N.W.)
Edward P. Molitor (N.J.)
Robert S. Phillips (N.C.)
Alfred Henry Weiters (Iowa)
William Homer Wisely (Cen. St.)

1944

Albert Edward Berry (Can.)
Van Porter Enloe (Ga.)
Albert Legrand Genter (Md.-Del.)
F. Wellington Gilcreas (New Eng.)
Charles A. Holmquist (N.Y.)
Dana Ewart Kepner (Rocky Mtn.)
Leon Benedict Reynolds (Calif.)
Wilson Waldo Towne (Dak.)

1945

Howard Eugene Moses (Pa.)
George S. Russell (Mo.)
Dario Travaini (Ariz.)
Frederick Holman Waring (Ohio)
Joe Williamson, Jr. (Fla.)
Murray Alderson Wilson (Kans.)

1946

E. J. M. Berg (Texas)
Frank E. DeMartini (Fed.)
John R. Downes (N.J.)
Thomas J. Doyle (Mich.)
John Henry Garner (ISP)
Harold Benedict Gotaas (N.C.)
William P. Hughes (Pac. N.W.)
Theodore R. Lovell (Iowa)
George W. Martin (Cen. St.)

1947

William T. Knowlton (Calif.)
Floyd W. Pinney (Dak.)
Gilbert R. Frith (Ga.)
Clarence E. Keefer (Md.-Del.)
Stuart E. Coburn (New Eng.)
Wellington Donaldson (N.Y.)
Henry J. Darcey (Okla.)
Carroll H. Coberly (Rocky Mtn.)
William Storrie (Can.)
William Merriam Cobleigh (Mont.)

1948

George W. Marx (Ariz.)
David Bryon Lee (Fla.)
William Q. Kehr (Mo.)
F. Dean Stewart (Ohio)
Francis deSales Friel (Pa.)

The Arthur Sidney Bedell Award

Established in 1948, the Arthur Sidney Bedell Award acknowledges extraordinary personal service to the Member Associations of the Federation. Each Member Association is privileged once in every three years to name one of its members to receive the award, which may be earned by organizational leadership, administrative service, membership activity, stimulation of technical functions, or similar participation. The award is named for the second President of the Federation, who exemplified its purpose by his long devotion and contribution to the affairs of the New York State Sewage Works Association.

Past recipients follow:

1949

Harry P. Croft (N.J.)
Victor Marcus Ehlers (Texas)
R. Paul Farrell (Ky.-Tenn.)
Carl Edwin Green (Pac. N.W.)
Frederick Leon McDonald (Ark.)
William Thomas Lockett (ISP)
William McKinney Piatt (N.C.)
Walter Asa Sperry (Cen. St.)
Harold Warner Streeter (Fed.)
John L. Strelow (Iowa)

1950

Leland Bradney (Dak.)
John Chester Brigham (N.Y.)
Herbert B. Foote (Mont.)
L. L. Hedgepeth (Va.)
Theodore J. Lafreniere (Can.)
Robert G. McCall (W. Va.)
Edward Alexander Reinke (Calif.)
Frank S. Taylor (Okla.)
LeRoy Winfield Van Kleeck (New Eng.)
William Hugh Weir (Ga.)
Leonard Oliver Williams, Jr. (Rocky Mtn.)
Abel Wolman (Md.-Del.)

1951

Roy Binder (Kans.)
John Clinton Clark (Ala.)
John Raymund Hoffert (Pa.)
John Robertson Hoy (Fla.)
Arthur H. Niles (Ohio)
Charles Henry Trusler (ISE)
Harold W. Yost (Ariz.)
Francis M. Veatch (Mo.)

1952

Don E. Bloodgood (Cen. St.)
Herman Glenn Baity (N.C.)
Paul Bolton (Iowa)
P. N. Daniels (N.J.)
Francis W. Kittrell (Ky.-Tenn.)
Ray E. Koon (Pac. N.W.)
Winfred S. Mahlie (Texas)
Clarence Theodore Mudgett (Mich.)
Walter F. Freeborn (ISP)
Harrison Hale (Ark.)
George Ashby Rhame (S.C.)

The William D. Hatfield Award

The William D. Hatfield Award recognizes outstanding annual sewage works operation reports. Following the 1946 award, the Board of Control authorized identical awards for outstanding annual reports prepared (I) for plants serving less than 10,000 population, (II) for plants serving populations of 10,000 to 100,000, and (III) for plants serving populations of more than 100,000 persons.

Recipients of this award have been:

1946

Walter M. Kunsch

1947

F. E. Peterson (I)
John R. Szymanski (II)
Warren H. Sleeger and George J. Schroepfer (III)

1948

F. E. Peterson (I)*
Thomas T. Hay (II)
Kerwin L. Mick (III)

1949

Russell D. Craun (I)
George W. Martin (II)
Thomas T. Hay (II)*

1950

William L. Edwards (I)
Walter A. Sperry (II)
John R. Szymanski (II)*
John W. Johnson (III)

1951

William L. Edwards (I)*
J. E. Meers (II)
John R. Szymanski (II)*
George H. Craemer (III)
Kerwin L. Mick (III)*

Membership Prizes

Prizes for membership activity in its various Member Associations have been awarded by the Federation since 1943. The following Member Associations have received these prizes:

Federal Sewage Research Assn. and Central States Sewage Works Assn.....1943
Missouri Water and Sewerage Conf. and Central States Sewage Works Assn.....1944
Arizona Sewage and Water Works Assn. and Canadian Institute on Sewage and Sanitation.....1945

* Previous winner.

Oklahoma Water and Sewage Conf. and Canadian Institute on Sewage and Sanitation.....1946
Institute of Sewage Purification (Eng.) and Arkansas Water and Sewage Conference.....1947
Pennsylvania Sewage and Industrial Wastes Association and West Virginia Sewage and Industrial Wastes Association....1948
Ohio Sewage and Industrial Wastes Treatment Conference and Alabama Water and Sewage Association.....1949
Ohio Sewage and Industrial Wastes Treatment Conference and Sewage Works Section, Louisiana Conference on Water Supply and Sewerage.....1950
Institution of Sanitary Engineers (England) and Michigan Sewage and Industrial Wastes Association.....1951
Central States Sewage and Industrial Wastes Association and Florida Sewage and Industrial Wastes Association.....1952

The Quarter Century Operators' Club

The Quarter Century Operators' Club is an informal group comprising Active or Corporate Members of any Member Association who had been engaged in sewage treatment works operation, on a full-time resident basis, twenty-five years prior to the date of their admission into the Club. The Club was created in 1941 under the sponsorship of Frank Woodbury Jones, who serves as its registrar. The roster:

*Charles C. Agar	Harry M. Freeburn	E. L. Nance
*Reuben A. Anderson	E. D. Fry	I. H. Nevitt
Harry M. Beaumont	Arnold H. Goodman	Arthur H. Niles
George C. Behnke	William P. Gyatt	John R. Palmer
Don E. Bloodgood	Wm. C. Hamm	Wm. M. Piatt
Julius W. Bugbee	George I. Hanson	Wm. A. Ryan
Raymond G. Case	William D. Hatfield	Theodore C. Schaetzle
E. Sherman Chase	*Charles C. Hommon	Glenn Searls
Stuart E. Coburn	Frank W. Jones	John S. Simmerman
Morris M. Cohn	Harry J. Krum	Willard R. Smith
Rodney E. Cook	Roy S. Lamphear	H. W. Streeter
P. N. Daniels	John V. Lewis	Myron W. Tatlock
Earl Devendorf	George S. Long	S. L. Tolman
John R. Downes	Winfield S. Mahlie	Henry Van Der Vliet
*Almon L. Fales	C. D. McGuire	Edwin B. Wagner
George E. Flower	*Paul Molitor, Sr.	Charles E. Wheeler, Jr.

ANNUAL MEETINGS AND CONVENTIONS

Annual Meeting Number	*Location*	*Date*
1	Chicago, Illinois†	October 16, 1928
2	New York, New York†	January 18, 1929
3	New York, New York†	January 14, 1930
4	New York, New York†	January 22, 1931
5	New York, New York†	January 22, 1932
6	New York, New York†	January 19, 1933
7	New York, New York†	January 18, 1934
8	New York, New York†	January 18, 1935
9	New York, New York†	January 16, 1936

* Deceased.
† Annual business meeting of Board of Control.

Annual Meeting Number	*Location*	*Date*
10	New York, New York†	January 22, 1937
11	New York, New York†	January 21, 1938
12	New York, New York†	January 20, 1939
13	New York, New York†	January 18, 1940
	Chicago, Illinois‡	October 3–5, 1940
14	New York, New York†	January 15, 1941
	New York, New York‡	October 9–11, 1941
15	Cleveland, Ohio§	October 22–24, 1942
16	Chicago, Illinois§	October 21–23, 1943
17	Pittsburgh, Pa.§	October 12–14, 1944
18	Chicago, Illinois†	October 17–18, 1945
19	Toronto, Ont., Can.§	October 7–9, 1946
20	Philadelphia, Pa.†	October 10, 1947
	San Francisco, Calif.‡	July 21–24, 1947
21	Detroit, Mich.§	October 18–21, 1948
22	Boston, Mass.§	October 17–20, 1949
23	Washington, D. C.§	October 9–12, 1950
24	St. Paul, Minn.§	October 8–11, 1951
25	New York, New York§	October 6–9, 1952

DIRECTORY OF COMMITTEES

1952–53

Constitutional Committees

(*See Article VI of By-laws*)

EXECUTIVE COMMITTEE OF THE BOARD OF CONTROL

E. Sherman Chase, *Chairman*

Earnest Boyce
L. J. Fontenelli
T. C. Schaetzle
Nicol MacNicol
H. D. Lyon
R. S. Rankin

PUBLICATIONS COMMITTEE

The Publications Committee arranges the technical programs for the annual conventions of the Federation and has general supervision of all publications of the Federation.

F. W. Gilcreas, *Chairman*
Rolf Eliassen, *Vice-Chairman*

L. L. Hedgepeth
F. W. Mohlman
G. A. Parkes
W. H. Wisely

ORGANIZATION COMMITTEE

The Organization Committee examines and reports to the Board on applications for membership in the Federation and endeavors to encourage the formation of new regional associations or conferences eligible for membership.

Harold W. Streeter, *Chairman*

Richard Hazen
Seth G. Hess

† Annual business meeting of Board of Control.
‡ Convention of membership-at-large.
§ Annual business meeting of Board of Control and convention of membership-at-large.

SEWAGE AND INDUSTRIAL WASTES PRACTICE COMMITTEE

The Sewage and Industrial Wastes Practice Committee reviews and directs for publication any resolution, report, or publication which establishes professional or technical standards in the name of the Federation. The following Manuals of Practice have been published under the direction of the committee:

No. 1—Occupational Hazards in Sewage Works (1944)
No. 2—Utilization of Sewage Sludge as Fertilizer (1946)
No. 3—Municipal Sewer Ordinances (1949)
No. 4—Chlorination of Sewage and Industrial Wastes (1951)
No. 5—Air Diffusion in Sewage Works (1952)

Morris M. Cohn, *Chairman*
D. E. Bloodgood, *Vice-Chairman*

E. B. Cobb
C. E. Keefer
Kerwin L. Mick
F. W. Mohlman
H. E. Orford
Langdon Pearse
L. W. Van Kleeck
F. M. Veatch
L. E. West
W. H. Wisely

Subcommittee on Sewer Maintenance

This subcommittee of the Sewage and Industrial Wastes Practice Committee has been directed to develop a Manual of Practice on "Maintenance of Sewers and Appurtenant Structures." The first draft of the manual is in preparation.

Leslie E. West, *Chairman*

John H. Brooks, Jr.
W. H. Brown, Jr.
G. E. Finck
Henry Fitch
Thos. B. Garry
B. H. Grout
L. J. Lukrofka
Grant Olewiler
R. L. Patterson
Roy E. Phillips
Richard Pomeroy
Robert P. Shea
Forest Weber

Subcommittee on Standardization of Units

This subcommittee of the Sewage and Industrial Wastes Practice Committee has been assigned to develop an approved schedule of units to be used in the reporting of plant operation and laboratory data. A committee of about forty members is at work.

H. E. Orford, *Chairman*

Subcommittee on Trickling Filters

This subcommittee of the Sewage and Industrial Wastes Practice Committee is engaged in the development of a Manual of Practice to be entitled "Trickling Filters—Their Characteristics and Loadings."

Kenneth V. Hill, *Chairman*

B. F. Hatch
W. S. Mahlie
Wm. E. Stanley

Subcommittee on Sewage Works Accounting

This subcommittee was created in 1946 for the purpose of developing a Manual of Practice on accounting procedures for municipal sewage works functions. Mimeographed copies of the manual in tentative form were made available for purchase in April, 1949.

F. M. Veatch, *Chairman*

G. J. Beiswanger
Alfred A. Estrada
E. A. Farmer
K. K. Wallace

S. I. Zack

Subcommittee on Paints and Protective Coatings

This subcommittee has the function of assembling experience and data on paints and protective coatings used in sewage works, to be presented with recommendations in the form of a manual. The subcommittee was created in 1946 and the first draft of the manual is now under review.

Kerwin L. Mick, *Chairman*

Virgil Anderson
J. W. Johnson
L. S. Kraus
W. T. McClenahan
F. W. Pinney
Walter A. Sperry

M. L. Robins

RESEARCH COMMITTEE

The Research Committee has the function of stimulating research work among the various Member Associations, and of cooperating with other organizations in the promotion of research.

H. Heukelekian, *Chairman*

D. E. Bloodgood
G. P. Edwards
M. B. Ettinger
H. A. Faber
H. W. Gehm
P. D. Haney
R. D. Hoak
P. W. Kabler
Max Katz
C. E. Keefer
R. M. Manganelli
P. H. McGauhey
H. J. Miles
F. W. Mohlman
W. Allen Moore
H. E. Orford
G. A. Rohlich
C. C. Ruchhoft
N. H. Sanborn
L. R. Setter
H. A. Trebler
L. W. Van Kleeck

Subcommittee on Toxicity of Industrial Wastes

This subcommittee of the Research Committee is functioning in three sections:

Section I. Critical review of literature; H. Heukelekian, *Chairman*, C. E. Barnes, P. Doudoroff, G. P. Edwards, F. W. Kittrell, C. E. Renn and R. F. Weston.

Section II. Development of methods for toxicity determinations on wastes; J. A. McCarthy, *Chairman*, S. E. Coburn, G. P. Edwards, E. Hurwitz, R. S. Ingols, C. C. Ruchhoft, W. W. Sanderson, C. M. Sawyer and R. F. Weston.

Section III. Development and standardization of bio-assay methods; P. Doudoroff, *Chairman*, B. G. Anderson, G. E. Burdick, P. S. Galtsoff, W. B. Hart, R. Patrick, E. R. Strong, E. W. Surber and W. M. Van Horn.

FINANCE COMMITTEE

The Finance Committee develops the annual operating budget of the Federation and affords guidance to the Board of Control in financial affairs.

W. J. Orchard, *Chairman*

Earnest Boyce
E. Sherman Chase

Special Committees

Committee on Awards

The Committee on Awards was created by the Board of Control on October 11, 1941. Functions of the committee are to advise the Board on matters of award procedures and to make recommendations as to the annual winners of the Eddy, Gascoigne, Emerson, and Industrial Wastes medals.

T. R. Hazeltine, *Chairman*

Phillip F. Morgan
Harold A. Thomas

Honorary Membership Committee

Authorized by the Board of Control on October 24, 1942, this committee comprises the President and four latest, living Past Presidents with the senior Past President as chairman. The committee reviews nominations for election to the grade of Honorary Member and makes recommendations to the Board on such nominations.

V. M. Ehlers, *Chairman*

Earnest Boyce
E. Sherman Chase
R. E. Fuhrman
A. H. Niles

Operator's Qualifications Committee

Authorized by the Board of Control on October 11, 1941, the Operator's Qualifications Committee is assigned to "establish minimal qualifications for operators of various classes of treatment works." The committee also has the duty of collecting and compiling data on present procedures in the licensing and certification of operators for reference to Member Associations.

L. W. Van Kleeck, *Chairman*

Benjamin Benas
T. C. Schaetzle

Industrial Wastes Committee

The Industrial Wastes Committee was created by the Board of Control on October 23, 1943, for the purpose of developing interest in this important field and to direct a program whereby the Federation may be of service in industrial waste problems.

R. W. Hess, *Chairman*
K. S. Watson, *Vice-Chairman*

R. R. Balmer
E. B. Besselievre
D. E. Bloodgood
H. W. Gehm
W. B. Hart
L. L. Hedgepeth
L. F. Oeming
C. N. Sawyer
Wm. S. Wise

Nominating Committee

The special Nominating Committee was created by the Board of Control on October 9, 1946, to function in an advisory capacity to the Election Committee. The Nominating Committee is to comprise the last five living Past Presidents, with the senior Past President as chairman.

G. S. Russell, *Chairman*

Earnest Boyce
V. M. Ehlers
R. E. Fuhrman
A. H. Niles

Quarter Century Operators' Club Committee

The special Quarter Century Operators' Club Committee was created by the Board of Control on October 9, 1946. It is the function of this Committee to establish eligibility requirements, process membership applications, maintain the roster, and supervise the activities of the Quarter Century Operators' Club.

Frank W. Jones, *Chairman*

W. P. Gyatt
Harold W. Streeter

Legislative Analysis Committee

The Legislative Analysis Committee was created by the Board of Control on October 17, 1945, to study legislation pertinent to the interests of the Federation and to serve the Board in advisory capacity.

David B. Lee, *Chairman*

V. W. Bacon
E. J. Cleary
C. E. Schwob
R. L. Winget

Constitution and By-Laws Committee

The Constitution and By-Laws Committee was created by the Board of Controls on October 10, 1947, to review and develop recommendations for the amendment of the Constitution and By-Laws of the Federation as may be deemed advisable under changing conditions.

C. A. Emerson, *Chairman*

F. S. Friel
W. J. Orchard
G. S. Russell
G. J. Schroepfer

Joint Committees With Other Associations

Joint Committee on Advancement of Sanitary Engineering

On October 5, 1952 the Board of Control authorized participation in the Joint Committee on Advancement of Sanitary Engineering with the American Society of Civil Engineers, American Water Works Association, American Public Health Association, and American Society for Engineering Education. The objectives of the committee are to study professional recognition of sanitary engineers, educational and training requirements, functional use in public health and military service, opportunities for employment, and similar matters.

FSIWA Representatives

R. E. Lawrence
D. F. Metzler
R. S. Rankin

Joint Committee on Chlorine Supply

On October 11, 1951, the Board of Control authorized participation in the Joint Committee on Chlorine Supply with the American Water Works Association and the Conference of State Sanitary Engineers. The objective of the committee is to study problems of chlorine supply and distribution in the water and sewage fields, and to develop recommendations for their solution.

FSIWA Representatives

L. H. Enslow — L. F. Oeming

L. L. Hedgepeth (Alternate)

Committee on Standard Methods of Sewage and Industrial Wastes Analysis

Created by the Board of Control on January 22, 1931, the Committee on Standard Methods of Sewage and Industrial Wastes Analysis has functioned with similar committees of the American Water Works Association and American Public Health Association in the production of the laboratory manual *Standard Methods for the Examination of Water and Sewage*. In 1947 the Federation became a joint publisher of this book with the above associations. The Tenth Edition is now in production.

G. P. Edwards, *Chairman*
R. S. Ingols, *Vice-Chairman*

L. D. Betz
D. E. Bloodgood
A. M. Buswell
S. E. Coburn
Keeno Fraschina
W. D. Hatfield
H. Heukelekian
R. D. Hoak
E. F. Hurwitz
J. E. Kinney
F. W. Kittrell
W. S. Mahlie
H. C. Marks
M. G. Mellon
E. W. Moore
M. Starr Nichols
Richard Pomeroy
M. L. Robins
C. C. Ruchhoft
W. W. Sanderson
C. N. Sawyer
G. E. Symons
R. F. Weston

Water, Sewage and Industrial Wastes Joint Committee on Critical Materials

This joint committee was formed on December 6, 1950, with representation by the American Water Works Association, the American Public Health Association, the Water and Sewage Works Manufacturers' Association, and the Federation. The committee is engaged in the analysis of problems of materials procurement and allocation to the construction and operation of water supply and waste disposal facilities during the present national emergency. It is now cooperating closely with the Water Resources Division of the National Production Authority.

FSIWA Representatives

R. E. Fuhrman — W. H. Wisely

Policy Advisory Committee, APHA Engineering Section

This joint committee was created in 1947 to advise the Council of the Engineering Section, American Public Health Association, on policies and activities of the Section relating to the field of environmental sanitation. Representation on the committee is held by national, regional, and state public health and sanitary engineering organizations.

FSIWA Representative

B. A. Poole

Special Convention Committees

Convention Management Committee

The function of this committee is to supervise details of the management of the Annual Meetings of the Federation.

T. T. Quigley, *Chairman*

J. R. Hoy
H. E. Schlenz
J. G. Stewart
W. H. Wisely

Meeting Place Committee

This committee reviews invitations received for the Annual Meetings of the Federation and makes recommendations to the Board of Control in regard to the time and place of such meetings.

E. Sherman Chase, *Chairman*

Earnest Boyce
Carl N. Brown
L. J. Fontenelli
E. M. Jones
J. G. Stewart
W. H. Wisely

Publicity and Attendance Committee

The function of this committee is to prepare publicity releases in connection with the Annual Meetings of the Federation and to direct the distribution of such material.

L. H. Enslow, *Chairman*

W. S. Foster
W. A. Hardenbergh

Membership Lists

SUMMARY OF MEMBERSHIP

(As of December 31, 1952)

Federation Members

Honorary Members	10
Associate Members	86
Member Associations	38
Active Members	5,382
Corporate Members	137

Net Membership of Member Associations *

Member Association	Active	Honorary	Corporate	Total
Alabama	31	—	5	36
Arizona	30	—	3	33
Arkansas	60	—	—	60
California	489	1	—	490
Canadian Inst.	387	—	—	387
Central States	561	3	24	588
Dakota	36	—	—	36
Federal	98	—	—	98
Florida	137	—	—	137
Georgia	37	—	—	37
Germany	34	—	—	34
Iowa	146	—	—	146
ISE (England)	24	—	—	24
ISP (England)	145	—	—	145
Kansas	70	—	—	70
Kentucky-Tennessee	94	—	4	98
Louisiana	5	—	—	5
Maryland-Delaware	57	—	—	57
Michigan	312	—	2	314
Missouri	36	—	1	37
Montana	41	—	6	47
Nebraska	14	—	—	14
New England	361	2	—	363
New Jersey	200	1	—	201
New York	600	1	15	616
North Carolina	112	—	—	112
Ohio	296	—	30	326
Oklahoma	30	—	—	30
Pacific Northwest	197	—	—	197
Pennsylvania	350	2	29	381
Puerto Rico	6	—	—	6
Rocky Mountain	59	—	—	59
South Carolina	17	—	1	18
Sweden†	—	—	—	—
Swiss	15	—	—	15
Texas	140	—	—	140
Virginia	78	—	12	90
West Virginia	77	—	5	82
Totals	5,382	10	137	5,529

* Not including Dual Members.

† Affiliation effective 1952, but memberships effective Jan. 1, 1953.

MEMBER ASSOCIATIONS

Alabama Water and Sewage Association—Sewage Works Section (Affiliated 1948).

Territory: State of Alabama.
President: C. Hammond; *Vice-President:* C. W. Veazey; *Director:* J. C. Clarke; *Treasurer:* D. H. McLean; *Secretary:* Alex O. Taylor, Box 69, Auburn, Ala.

Arizona Sewage and Water Works Association—Sewage Works Section (Affiliated 1928).

Territory: State of Arizona.
President: M. P. Goudy; *First Vice-President:* W. Harford; *Second Vice-President:* R. G. Baker; *Director:* L. O. Gardner; *Secretary-Treasurer:* M. V. Ellis, Supt., Sewage Treatment Plant, 46 W. Encanto Blvd., Phoenix, Ariz.

Arkansas Water and Sewage Conference—Sewage Works Section (Affiliated 1946).

Territory: State of Arkansas.
Chairman: J. J. Highfill; *Vice-Chairman:* J. Wilson; *Director:* G. T. Kellogg; *Secretary-Treasurer:* Harrison Hale, Southern State College, Magnolia, Ark.

California Sewage and Industrial Wastes Association (Affiliated 1928).

Territory: State of California.
President: Arthur G. Pickett; *First Vice-President:* Lawrence H. Cook; *Second Vice-President:* A. A. Appel; *Director:* K. A. Keirn; *Secretary-Treasurer:* Sam A. Weed, Rm. 315, City Hall, Oakland, Calif.

Canadian Institute on Sewage and Sanitation (Affiliated 1933).

Territory: Dominion of Canada.
President: G. H. Baker; *Vice-President:* A. E. Chalmers; *Director:* Nicol MacNicol; *Secretary-Treasurer:* A. E. Berry, Ontario Dept. of Health, Parliament Buildings, Toronto, Ont., Can.

Central States Sewage and Industrial Wastes Association (Affiliated 1928).

Territory: States of Illinois, Indiana, Wisconsin, and Minnesota.
President: W. W. Mathews; *First Vice-President:* E. Hurwitz; *Second Vice-President:* O. J. Muegge; *Third Vice-President:* A. J. Duvall; *Director:* W. D. Hatfield; *Secretary-Treasurer:* A. Paul Troemper, c/o Illinois Sanitary Water Board, Springfield, Ill.

Dakota Water and Sewage Works Conference—Sewage Works Sections (Affiliated 1936).

North Dakota Section

Territory: State of North Dakota.
President: C. T. Stephenson; *Vice-President:* C. M. Hagen; *Director:* R. J. Stapf; *Secretary-Treasurer:* Jerome H. Svore, c/o State Dept. of Health, Bismarck, N. Dak.

South Dakota Section

Territory: State of South Dakota.
President: A. T. Hanson; *Vice-President:* D. Wessel; *Director:* R. J. Stapf; *Secretary-Treasurer:* Charles E. Carl, c/o State Board of Health, Div. of Sanitary Engineering, Pierre, S. Dak.

Federal Sewage Research Association (Affiliated 1930).

Territory: Federal employees wherever stationed.
President: L. B. Dworsky; *Vice-President:* R. S. Smith; *Director:* Robert N. Clark; *Secretary-Treasurer:* Wm. Davis, Federal Sewage Research Assn., Room 4218, Fed. Security Bldg., So., Washington 25, D. C.

Florida Sewage and Industrial Wastes Association (Affiliated 1941).

Territory: State of Florida.
President: John W. Wakefield; *Vice-President:* W. C. Tims; *Director:* J. R. Hoy; *Secretary-Treasurer:* Donald P. Schiesswohl, Florida State Board of Health, P. O. Box 210, Jacksonville 1, Fla.

Georgia Water and Sewage Association—Sewage Works Section (Affiliated 1936).

Territory: State of Georgia.
President: L. C. Bowen; *Vice-President:* S. Russell; *Director:* R. S. Ingols; *Asst. Secretary-Treasurer:* I. C. Kelley; *Secretary-Treasurer:* A. T. Storey, 1210 Hemphill Ave. N. W., Atlanta, Ga.

German Sewage Technologists Association (Affiliated 1950).
(Abwassertechnische Vereinigung)

Territory: Western Germany.
President: Max Prüss; *Vice-President:* Franz Schreier; *Director:* Karl Imhoff; *Secretary-Treasurer:* Wilhelm Bucksteeg, Schliessfach 1112, Ruhrverband, Essen, Germany.

Institute of Sewage Purification—England (Affiliated 1932).

Territory: British Empire.
President: F. C. Vokes; *Director:* Martin Lovett; *Honorary Secretary:* W. F. Freeborn; *FSIWA Contact Member:* Martin Lovett, 206 Bradford, Wakefield, Yorkshire, Eng.

Institution of Sanitary Engineers—England (Affiliated 1932).

Territory: British Empire.
President: S. Brassey-Edwards; *Vice-Presidents:* W. E. Fretwell, A. Johnson, *and* E. H. Vick; *Director:* C. B. Townend; *Treasurer:* A. Seiver; *Secretary:* Ernest V. Balsom, 118 Victoria St., Westminster, S. W. 1, London, England.

Iowa Sewage Works Association (Affiliated 1928).

Territory: State of Iowa.
President: J. L. Strelow; *Vice-President:* H. F. Seidel; *Director:* P. J. Houser; *Secretary-Treasurer:* Leo Holtcamp, P. O. Box 310, Webster City, Ia.

Kansas Sewage and Industrial Wastes Association (Affiliated 1935).

Territory: State of Kansas.
Chairman: H. L. Ramage; *Vice-Chairman:* W. Parr; *Director:* G. E. Mau; *Secretary-Treasurer:* D. F. Metzler, c/o State Board of Health, Marvin Hall, University of Kansas, Lawrence, Kans.

Kentucky-Tennessee Industrial Wastes and Sewage Works Association (Affiliated 1946).

Territory: States of Kentucky and Tennessee.
Chairman: H. D. Regan; *Vice-Chairman:* K. B. Stallings; *Director:* F. W. Kittrell; *Secretary-Treasurer:* R. P. Farrell, 420 Sixth Ave. N., Nashville, Tenn.

Louisiana Conference on Water Supply and Sewerage—Sewage Works Section (Affiliated 1949).

Territory: State of Louisiana.
Chairman: J. C. Pittman; *Vice-Chairman:* A. J. Meyers; *Director:* J. J. Holtgreve; *Secretary-Treasurer:* G. H. West, Lake Charles, La.

Maryland-Delaware Water and Sewerage Association—Sewage Works Section (Affiliated 1928).

Territory: States of Maryland and Delaware.
President: V. W. Faivre; *First Vice-President:* R. H. Ritter; *Second Vice-President:* E. F. Donaldson; *Director:* W. M. Bingley; *Secretary-Treasurer:* W. M. Bingley, 2411 N. Charles St., Baltimore 18, Md.

Michigan Sewage and Industrial Wastes Association (Affiliated 1930).

Territory: State of Michigan.
President: W. E. Smith; *First Vice-President:* K. Fishbeck; *Second Vice-President:* H. Oehlke; *Director:* C. L. Palmer; *Secretary-Treasurer:* D. M. Pierce, Michigan Dept. of Health, Room 334, Administration Bldg., Lansing 4, Mich.

Missouri Water and Sewerage Conference—Sewage Works Section (Affiliated 1929).

Territory: State of Missouri.
Chairman: William B. Schworm; *Vice-Chairman:* James Ramsey; *Director:* L. J. Lukrofka; *Secretary-Treasurer:* Warren A. Kramer, c/o State Office Bldg., Sixth Fl., Jefferson City, Mo.

Montana Sewage and Industrial Wastes Association (Affiliated 1944).

Territory: State of Montana.
Chairman: S. B. Ward; *Vice-Chairman:* C. H. King; *Director:* Earl Eby; *Secretary-Treasurer:* H. W. Taylor, Div. of Sanitary Eng., State Board of Health, Helena, Mont.

Nebraska Sewage and Industrial Wastes Association (Affiliated 1952).

Territory: State of Nebraska.
President: M. S. Fitzsimmons; *Vice-President:* C. Welton; *Director:* S. Wilber; *Secretary-Treasurer:* Paul W. Mousel, 602 W. B St., McCook, Neb.

New England Sewage and Industrial Wastes Association (Affiliated 1929).

Territory: States of Maine, New Hampshire, Vermont, Massachusetts, Connecticut, and Rhode Island.
President: E. L. Bond; *First Vice-President:* C. G. Hamman; *Second Vice-President:* W. E. Merrill; *Director:* W. H. Brown, Jr.; *Secretary-Treasurer:* Steven M. Hurley, Jr., c/o State Dept. of Health, 331 State Office Bldg., Providence, R. I.

New Jersey Sewage and Industrial Wastes Association (Affiliated 1942).

Territory: State of New Jersey.
President: Sol Seid; *First Vice-President:* J. W. Hood; *Second Vice-President:* J. Collom; *Director:* Henry Van Der Vliet; *Secretary-Treasurer:* M. S. Kachorsky, P. O. Box 766, Manville, N. J.

New York Sewage and Industrial Wastes Association (Affiliated 1930).

Territory: State of New York.
President: W. R. Schreiner; *Vice-President:* H. A. Faber; *Director:* W. H. Larkin; *Treasurer:* J. C. Brigham; *Secretary:* R. C. Sweeney, c/o State Dept. of Health, 21 N. Broadway, White Plains, N. Y.

North Carolina Sewage and Industrial Waste Association (Affiliated 1929).

Territory: State of North Carolina.
Chairman: J. L. Greenlee; *Vice-Chairman:* W. B. Snow; *Director:* P. D. Davis; *Secretary-Treasurer:* E. C. Hubbard, Executive Secretary, State Stream Sanitation Committee, Raleigh, N. C.

Ohio Sewage and Industrial Wastes Treatment Conference (Affiliated 1932).

Territory: State of Ohio.
Chairman: Donald G. Stevens; *First Vice-Chairman:* W. D. Sheets; *Second Vice-Chairman:* G. Pettit; *Director:* T. C. Schaetzle; *Secretary-Treasurer:* Ward E. Conrad, 301 Ohio Depts. Bldg., Columbus 15, Ohio.

Oklahoma Water, Sewage and Industrial Waste Conference—Sewage Works Section (Affiliated 1929).

Territory: State of Oklahoma.
President: Bernal H. Swab; *Vice-President:* L. Barngrover; *Director:* J. T. Sprague; *Secretary-Treasurer:* H. J. Darcey, State Dept. of Health, Oklahoma City 5, Okla.

Pacific Northwest Sewage and Industrial Wastes Association (Affiliated 1933).

Territory: States of Washington, Oregon, and Idaho.
President: C. M. Everts, Jr.; *Vice-President:* J. H. Melton; *Director:* W. P. Hughes; *Secretary-Treasurer:* R. O. Sylvester, c/o Div. of Sanitary Engineering, More Hall, University of Washington, Seattle 5, Wash.

Pennsylvania Sewage and Industrial Wastes Association (Affiliated 1928).

Territory: State of Pennsylvania.
President: R. F. Weston; *First Vice-President:* T. R. Haseltine; *Second Vice-President:* G. Weist; *Director:* H. T. Reuning; *Secretary-Treasurer:* B. S. Bush, c/o Pennsylvania Dept. of Health, Kirby Health Center, Wilkes-Barre, Pa.

Puerto Rico Water and Sewage Works Association (Affiliated 1947).

Territory: Puerto Rico.
President: E. F. Saavedra; *Vice-President:* R. Bras; *Director:* Felipe Bosch; *Secretary-Treasurer:* Robert J. Auld, c/o Puerto Rico Aqueduct & Sewer Service, Box 2832, San Juan 12, P. R.

Rocky Mountain Sewage Works Association (Affiliated 1947).

Territory: States of Wyoming, Colorado, and New Mexico.
President: C. H. Coberly; *Vice-President:* John Frederick; *Director:* C. G. Caldwell; *Secretary-Treasurer:* C. E. Harness, City Engineer, 272 City and County Bldg., Denver, Colo.

South Carolina Water and Sewage Works Association—Sewage Works Section (Affiliated 1949).

Territory: State of South Carolina.
Chairman: M. Bright; *Vice-Chairman:* F. Gibson; *Director:* T. E. Robertson, Jr.; *Secretary-Treasurer:* W. T. Linton, Wade Hampton Bldg., Columbia, S. C.

Swedish Association for Water Hygiene (Affiliated 1952).
(Föreningen För Vattenhygien)

Territory: Sweden.
President: S. Vallin; *Director:* N. Westberg; *Secretary:* Sten Hesser, Box 5038, Stockholm 5, Sweden.

Swiss Association of Water and Sewage Professionals (Affiliated 1947).
(Association Suisse Des Professionels De L'Epuration Des Eaux)

Territory: Switzerland.
President: A. Kropf; *Vice-President:* F. Schneiter; *Director:* E. Holinger; *Treasurer:* E. Holinger; *Secretary:* F. Baldinger, im Quell 252, Rohr/Aargau, Switzerland.

Texas Water and Sewage Works Association—Sewage and Industrial Wastes Section (Affiliated 1928).

Territory: State of Texas.
Chairman: A. H. Ullrich; *Vice-Chairman:* A. C. Bryan; *Director:* E. W. Steel; *Secretary:* V. M. Ehlers, 501 W. 33 St., Austin, Tex.; *Assistant Secretary and Treasurer:* Mrs. Earl H. Goodwin.

Virginia Industrial Wastes and Sewage Works Association (Affiliated 1947).

Territory: State of Virginia.
President: S. H. Reaves; *Vice-President:* S. R. Evans; *Director:* E. C. Meredith; *Secretary-Treasurer:* J. L. Hamrick, 415 West Franklin St., Richmond 20, Va.

West Virginia Sewage and Industrial Wastes Association (Affiliated 1947).

Territory: State of West Virginia.
President: A. R. Todd; *First Vice-President:* W. D. Kelley; *Second Vice-President:* J. F. Vogler; *Director:* H. D. Lyon; *Secretary-Treasurer:* G. O. Fortney, State Department of Health, Charleston, W. Va.

HONORARY MEMBERS

Bugbee, Julius W. (1942), 246 Lowell Ave., Providence 9, R. I.

DeBerard, Wilford Willis (1950), City Engr., Bur. of Eng., Dept. of Pub. Works, 402 City Hall, Chicago 2, Ill.

Emerson, Charles A. (1941), Cons. Engr., Havens & Emerson, Woolworth Bldg., New York 7, N. Y.

Gilcreas, F. Wellington (1948), Asst. Dir., Div. of Lab. & Research, State Dept. of Health, New Scotland Ave., Albany 1, N. Y.

Hyde, Charles Gilman (1943), Cons. Engr., 2495 Shattuck Ave., Berkeley 4, Calif.

Mohlman, Dr. Floyd W. (1944), Dir., Div. of Lab., Sanitary Dist. of Chicago, 910 S. Michigan Ave., Chicago 5, Ill.

Moses, Howard E. (1943), Chief Sanitary Engr., State Dept. of Health, 1522 N. Second St., Harrisburg, Pa.

Orchard, William J. (1946), Gen. Mgr., Wallace & Tiernan Co., Inc., Newark 1, N. J.

Pearse, Langdon (1942), Sanitary Engr., Sanitary Dist. of Chicago, 910 S. Michigan Ave., Chicago 5, Ill.

Rudolfs, Dr. Willem (1945), Chief, Dept. of Sanitation, Agr. Experiment Sta., Short Course Bldg., New Brunswick, N. J.

ASSOCIATE MEMBERS

Albert Pipe Supply Co., Inc., Berry & North 13th St., Brooklyn 11, N. Y., Rep. J. J. Dougherty.

Aluminum Co. of America, New Kensington, Pa., Rep. R. C. Kasser.

American Car and Foundry Co., 1501 E. Ferry Ave., Detroit 11, Mich., Rep. William A. Gormley, Sales Mgr., Valve Div.

American Cast Iron Pipe Co., Birmingham, Ala., Rep. E. L. Gilder.

American City Magazine, 470 Fourth Ave., New York, N. Y., Rep. Edgar J. Buttenheim, Pres.

American Concrete Pipe Assn., 228 N. LaSalle St., Suite 1033, Chicago 1, Ill., Rep. Howard F. Peckworth, Managing Dir.

American Lumber & Treating Co., 332 S. Michigan Ave., Chicago 4, Ill., Rep. J. E. L. McCall, Adv. Mgr.

American Well Works, Aurora, Ill., Rep. L. H. Kramer, Exec. Vice-Pres.

Armco Drainage & Metal Products, Inc. (Armco Steel Corp.), Middletown, Ohio, Rep. W. H. Spindler, Pub. Mgr.

Automatic Control Co., 1005 University Ave., St. Paul 4, Minn., Rep. J. S. Williams.

Bristol Co., Waterbury, Conn., Rep. F. W. Borchers, Asst. Sales Mgr.

Builders-Providence, Inc., Div. of Builders Iron Foundry, P. O. Box 1342, Providence, R. I., Rep. W. H. Brown, Jr.

Carter, Ralph B., Co., 192 Atlantic St., Hackensack, N. J., Rep. J. J. Horgan.

Chain Belt Co., Milwaukee, Wis., Rep. W. B. Marshall.

Chapman Valve Mfg. Co., 203 Hampshire St., Indian Orchard, Mass., Rep. Donald M. Belcher.

Chicago Pump Co., 622 Diversey Parkway, Chicago 14, Ill., Rep. Milton Spiegel, Vice-Pres.

Clay Products Assn., 100 N. LaSalle St., Chicago, Ill., Rep. J. D. Cook.

Climax Engine & Pump Mfg. Co., 208 N. LaSalle St., Chicago 4, Ill., Rep. E. D. West, Mgr.

Cloroben Corp., 225 Mercer St., Jersey City 2, N. J., Rep. Herman Seydel, Pres.

Combustion Engineering-Superheater, Inc., Flash Dryer Div., 1315 N. Branch St., Chicago 22, Ill., Rep. C. W. Gordon, Mgr.

Crane Co., 836 S. Michigan Ave., Chicago 5, Ill., Rep. J. R. Cella.

DeLaval Steam Turbine Co., Trenton 2, N. J., Rep. J. P. Stewart, Exec. Vice-Pres.

Dickey Clay Mfg. Co., W. S., 607 Commerce Trust Bldg., Kansas City, Mo., Rep. A. G. Frerking, Vice-Pres. & Sales Mgr.

Dorr Co., Barry Pl., Stamford, Conn.

Elmco Corp., 3319 S. Wallace St., Chicago 16, Ill., Rep. Paul O. Richter, Mgr., Central Div.

Engineering News-Record, 330 W. 42nd St., New York 36, N. Y.

Engineering Sales Corp., 2300 Washington St., Newton Lower Falls 62, Mass., Rep. Fred S. Gibbs.

Everson Mfg. Co., 214 W. Huron St., Chicago 10, Ill., Rep. R. B. Everson, Pres.

Fairbanks, Morse & Co., 80 Broad St., New York 4, N. Y., Rep. Charles J. Prestler, Mgr., Pump Sales.

Fischer & Porter Co., Hatboro, Pa., Rep. Edward H. Elliott, Field Engr.

Flexible Sewer-Rod Equip. Co., 9059 Venice Blvd., Los Angeles, Calif., Rep. Peter L. Ciaccio, Mgr.

Foxboro Co., Foxboro, Mass., Rep. Russell H. Babcock, Asst. Mgr., Util. Ind. Div.

Gale Oil Separator Co., 52 Vanderbilt Ave., New York, N. Y., Rep. William A. Gehle, Pres.

General Chemical Div., Allied Chemical & Dye Corp., Edgewater, N. J., Rep. R. W. Ockershausen, Div. of Tech. Service.

General Electric Co., 1 River Rd., Schenectady, N. Y., Rep. H. R. Wallrath.

General Laboratory Supply Co., 320 Market St., Paterson 3, N. J., Rep. I. T. Klein.

Glamorgan Pipe & Foundry Co., Lynchburg, Va., Rep. John D. Capron.

Green Bay Foundry & Machine Works, 401 S. Broadway, Green Bay, Wis., Rep. James P. North, Pres.

Gruendler Crusher & Pulverizer Co., 2915 N. Market St., St. Louis 6, Mo., Rep. William P. Gruendler.

Hardinge Co., York, Pa., Rep. M. C. Fleming.

Hersey Mfg. Co., Corner of E. and Second Sts., S. Boston 27, Mass., Rep. William C. Sherwood.

Homelite Corp., Port Chester, N. Y., Rep. Nelson Thompson.

Inertol Co., Inc., 480 Frelinghuysen Ave., Newark 5, N. J., Rep. K. T. Fezer, Pres.

Infilco Inc., P. O. Box 5033, Tucson, Ariz., Rep. H. W. Gillard.

Iowa Valve Co., 201 N. Talman Ave., Chicago, Ill., Rep. J. W. Dousette, Gen. Sales Mgr.

Jeffrey Mfg. Co., Columbus 16, Ohio, Rep. S. L. Tolman.

Johns-Manville Corp., 22 E. 40th St., New York 16, N. Y., Rep. R. F. Orth.

Josam Mfg. Co., Michigan City, Ind., Rep. Leo N. Newman.

Komline-Sanderson Eng. Corp., P. O. Box 257, Peapack, N. J., Rep. T. R. Komline, Pres.

Koppers Co., Inc., Tar Products Div., Pittsburgh 19, Pa., Rep. K. P. Stearns, Mgr., Adv. & Promotion.

Lakeside Eng. Corp., 222 W. Adams St., Chicago 6, Ill., Rep. R. O. Friend.

Lignum-Vitae Products Corp., 96-100 Boyd Ave., Jersey City, N. J., Rep. Samuel E. Gold, Sales Mgr.

Limestone Products Corp. of America, Newton, N. J., Rep. Peter J. Kelley, Service Rep.

Link-Belt Co., 2045 W. Hunting Pk. Ave., Philadelphia, Pa., Rep. William L. Hartley.

Lock Joint Pipe Co., E. Orange, N. J. Rep. F. F. Longley, Vice-Pres.

Lynchburg Foundry Co., Lynchburg, Va., Rep. W. Roy Odor.

Mathieson Chemical Corp., Mathieson Bldg., 10 Light St., Baltimore 3, Md., Rep. J. O. Logan.

Mine Safety Appliances Co., Braddock, Thomas & Meade Sts., Pittsburgh, Pa., Rep. N. R. Chillingworth.

Minneapolis-Honeywell Regulator Co., Wayne & Windrim Aves., Philadelphia 44, Pa., Rep. W. H. Sisson, Industry Mgr.

Morse Boulger Destructor Co., Sewage & Waste Div., 205 E. 42nd St., New York 17, N. Y., Rep. Warren S. Martin, Mgr.

Mueller Co., 512 W. Cerro Gordo St., Decatur, Ill., Rep. H. L. Baker.

National Water Main Cleaning Co., 30 Church St., New York, N. Y., Rep. J. A. Frank, Pres.

Nichols Eng. & Research Corp., 60 Wall Tower, New York, N. Y., Rep. R. W. Rowen.

Omega Machine Co., 9 Codding St., Providence, R. I., Rep. L. E. Harper.

Pacific Flush Tank Co., 4241 Ravenswood Ave., Chicago, Ill., Rep. L. E. Rein.

Pettinos, Inc., George F., 1206 Locust St., Philadelphia 7, Pa., Rep. Louis Dill, Sec.

Pittsburgh-Des Moines Co., Neville Island Branch, Pittsburgh, Pa., Rep. J. E. O'Leary.

Pittsburgh Pipe Cleaner Co. of N. Y., Inc., 990 Broad St., Newark, N. J., Rep. Kyle I. Robinson, Pres.

Preload Corp., 211 E. 37th St., New York 16, N. Y., Rep. E. H. Thwaits, Vice-Pres.

Proportioneers, Inc., P. O. Box 1442, Providence, R. I.

Public Works Magazine, 310 E. 45th St., New York, N. Y., Rep. W. A. Hardenbergh.

Rockwell Mfg. Co., Pittsburgh Equitable Meter Div., 400 N. Lexington Ave., Pittsburgh, Pa., Rep. G. H. Gleeson.

Royer Foundry & Machine Co., 158 Pringle St., Kingston, Pa., Rep. S. B. Davies, Pres.

Simplex Valve & Meter Co., 68th & Upland Sts., Philadelphia, Pa., Rep. Everett M. Jones, Sales Mgr.

Smith Mfg. Co., A. P., 545 N. Arlington Ave., E. Orange, N. J., Rep. W. P. Baerenrodt.

Stewart, Inc., W. H., P. O. Box 767, Syracuse, N. Y., Rep. W. H. Stewart, Pres.

Vapor Recovery Systems Co., 2820 N. Alameda St., Compton, Calif., Rep. F. V. Long, Pres.

Walker Process Equipment, Inc., 33 Hoyt Pl., Aurora, Ill., Rep. J. D. Walker, Pres.

Wallace & Tiernan Co., Inc., 11 Mill St., Belleville, N. J., Rep. T. T. Quigley.

Warren Foundry & Pipe Corp., 55 Liberty St., New York 5, N. Y., Rep. John F. Benjamin, Vice-Pres. in Charge of Sales.

Wastes Engineering, 24 W. 40th St., New York, N. Y., Rep. Karl M. Mann.

Water & Sewage Works, 155 E. 44th St., New York, N. Y., Rep. E. S. Gillette.

Westinghouse Electric Corp., E. Pittsburgh, Pa., Rep. William L. James.

Wood Co., R. D., Public Ledger Bldg., Independence Sq., Philadelphia 5, Pa., Rep. Theodore W. Wood.

Worthington Pump & Machinery Corp., Harrison, N. J., Rep. T. Cruthers, Vice-Pres.

Yeomans Brothers Co., 1999 N. Ruby St., Melrose Park, Ill., Rep. Charles Yeomans, Pres.

MEMBERSHIP OF MEMBER ASSOCIATIONS

By direction of the Board of Control on October 7, 1951, the alphabetical directory of Active and Corporate Members of the Member Associations will henceforth be published in the March issue of the JOURNAL only in alternate years. This having been done last in 1952, such directories in the future will appear in the even-numbered years. The Board has directed further that a listing of names only of Active and Corporate Members of the Member Associations be published in the March issue of odd-numbered years, beginning with this issue.

The listing presented here groups the names of members according to Member Associations. Addresses are given in the Consolidated Membership Directory on pages 355–422 of the March, 1952 issue, except for new and reinstated members in 1952, whose names are designated here by an asterisk (*).

ALABAMA WATER AND SEWAGE ASSOCIATION

American Cast Iron Pipe Co.
(E. L. Gilder)
Beck, Arthur N.
Birmingham Slag Co.
(W. H. Caruthers)
Bolton, John M., Jr.
Byrd, Kenneth D.
Clarke, J. C.
Coggin, Benton G., Jr.
Cook, Leland B.
Crockett, J. L., Jr.*
Dunstan, Gilbert H.
Gilmore, W. H.*
Gran, John E.
Gray, C. L.
Howse, B. C.
Jordan, L. L.
Krebs, Paul B.
Longview Lime Corp.
(Warren Lewis)
McCreery, Thomas W.
McIlvaine, W. D., Jr.
McLean, John W.
Mitcham, George N.
Moore, Thomas E.
Pradat, J. E.
Rae, Robert D.
Robinson, Philip L.
Samuel, W. L.
Scott, Fred, Jr.
Scott, W. R.
Strange, Forrest R.
Taylor, Alex O.
Ulrich, Julius P.
Waldrop, Owen
White, Charles W.
Willis, William T.
Wittichen Chemical Co.
(W. O. Mullins)
Wittichen Chemical Co.
(W. A. Ames)

ARIZONA SEWAGE AND WATER WORKS ASSOCIATION

Arizona Concrete Pipe Co.*
Bennett, Richard
Brinkerhoff, W.
Brown, Eugene M.*
Carney, Harold E.*
Carollo, John A.
Cecil, Lawrence K.
Clements, Howard *
Concrete Conduit Co.
Cushing, Robert M.
Davenport, G. L., Jr.
Ellis, M. V.
Fitch, Reamy C.*
Gardner, Leigh O.*
Hall, Walter C.
Hastain, James E.
Hausmann, A. R.
Henderson, Stuart P.
Jordan, Harry S.
Marum, Edmond F.*
Marx, George
Mathis, Alice L.
McLean, Claude E.
Miller, Alden W.
Padgett, J. W.
Rotthaus, Helen
Stufflebean, John H.
Travaini, Dario
Trygg, Charles
Tucson, City of
(A. E. Ferguson) *
Tyson, J. H.
Webb, Clark
Yost, Harold W.

ARKANSAS WATER AND SEWAGE CONFERENCE

Ames, L. C.
Baughn, R. N.
Bell, William E.
Blalock, E. E.*
Busby, A. L.*
Carter, Gerald R.
Clapham, T. W.
Clayton, Harry H.
Conway, Hollis R.
Cowsert, E. L.*
Crawford, Wyatt B.*
Crist, Marion L.
Curry, Allan
Dameron, Zack *
Dees, Ben W.
Dickinson, W. D.
Embree, Lon J.
Faye, John *
French, C. H.
Gerleman, Kenneth F.*
Hale, Harrison
Hampton, E. G.
Haws, Ray C.
Heagler, A. E.
Heiple, Loren R.
Herron, J. T.*
Highfill, J. J.
Hubbard, Carl *
Jackson, John S.
Johnson, D. O.
Jones, Mervyn
Kellogg, Glen T.*
Lambert, E. A.
Lefever, K. W.
Lewis, Frank L.
Mahaffey, John E.
Marti, George *
McConnell, Otis
McDonald, F. L.
McGoodwin, L. M.
Mehlburger, Max A.
Nott, Arthur C.*
Osborne, J. L.
Phillips, M. H.
Poston, H. W.
Powell, Nixon W.*
Powers, John B.
Pryor, Porter L.
Sanderson, Solon
Seabolt, M. L.
Sellner, Edward P.
Spratt, Eugene C.
Steward, W. R.
Thayer, Neal B.
Thomas, Charles O.
Thomas, M. H.*
Wood, Marvin L.*
Woolsey, Lawrence S.
Zander, Paul M.*
Zinn, Clyde

CALIFORNIA SEWAGE AND INDUSTRIAL WASTES ASSOCIATION

Albers, J. C.
Alderman, Frank E.
Aldrich, Lloyd
Allin, John R.
Alvarez, H. R. R.*
Ambrosini, Arnold T.
Anaya, Marvin
Anderson, Alva L.
Anderson, Guy H.
Anderson, Norman W.
Anderson, William A.
Andrus, Robert G.
Anton, Louis A.*
Antrim, R. T.
Appel, Alvin A.
Arness, Carl H., Jr.*
Arnold, Gerald E.
Bacon, Vinton W.
Baldwin, R. L.
Banks, Harvey O.
Bardin, William J.
Bargman, Robert D.
Barlow, Willis D.
Barney, Warren A.
Barry, Lester S.
Beardsley, C. W.
Beeman, Douglas H.*
Bejcek, Otto J.
Bejma, Leonard J.*
Belick, Frank M.
Bell, Anthony E.
Bell, John W.
Belt, Elmer H.
Benas, Benjamin
Bennett Eng. Co.
Betz, Jack M.
Bernasconi, L. C.
Bertrando, B. R.*
Blakeley, Loren E.
Boardman, John *
Bogost, Meyer S.
Bolin, R. R.*
Bonderson, Paul R.
Bondietti, Lester
Borland, Victor J.
Borrie, Edwin F.
Bossche, H. C.
Bothwell, John I.*
Bower, Noble
Bowlus, Fred D.
Boyle, J. R.
Braun, Leo
Bravender, Norris F.*
Brewer, Robert
Brodie, Omer H.
Brookman, H. R.
Broughton, John R.
Brown, Kenneth W.
Browning, Glen E.*
Bruce, Donald A.

Brunty, Clarence E.
Buchanan, H. C.*
Bulot, Francis H.
Burgess, Kenney *
Burnson, Blair I.
Burt, Gordon L.
Busch, Carl G.
Bush, Albert F.
Buss, Edward W.
Caldwell, David H.
Carey, James L.
Carnahan, Charles T.
Carroll, T. M.
Cary, Edmund S.
Chamberlain, L. H.
Chang, Howard T.
Chanin, Gerson *
Chapman, Harry C.
Chartier, Fred O.
Chutter, W. H.
Ciaccio, P. L.
Clark, J. C.
Clausen, Ervin H.*
Cleveland, Gilbert
Coffey, L. E.
Cole, Harvey M., Jr.
Collins, A. Preston
Collins, Roy G.*
Collins, Thomas F.
Compton, C. R.
Connors, Joseph J.
Cook, Lawrence H.
Cook, Leland, Jr.
Cooley, E. C.
Copeland, Kern H.
Coppa, G. J.
Corry, James
Crafts, John H.
Creears, Tom H.
Cretzler, Don J.
Critchlow, David M.
Crummey, Charles A.*
Culver, John R.
Cummins, Neil J.
Currie, David H.
Currie, Frank S.
Curry, W. G.*
Darnell, Floyd M.
Davids, E. M.
Davidson, J. F.
Davey, Harold W.
Davis, Glen *
DeMartini, Frank E.
Derby, Ray L.
DeWante, Randolph H.
Dierker, Fred H., Jr.
Dillashaw, E. J.*
Dinsmoor, D. S.*
Dirk, Marvin P.*
Driggs, E. Ogden
Duckel, Sherman P.
Dye, R. D.
Early, Fred J., Jr.
Easley, Glenn E.
Easthagen, J. H.
Eastling, Harvey V.
Eddy, Harrison P., Jr.
Egan, J. H.
Ellis, Watson
Eich, Henry F.
Faris, Cecil R.*
Farnum, Norman W.
Farr, Leo Grant, Jr.
Fassel, James E.*
Faulkner, Wm. J.
Fee, John R.*
Fenchel, Randolph
Fetzer, Clari A.
Flewelling, George F.
Finster, Edwin H.
Fish, Raymond S.
Flannery, H. J.*
Foster, H. B., Jr.
Fraschina, K.
Frick, A. L., Jr.
Galloway, Robert N.
Gannon, John J.
Gannon, Timothy J.
Garber, William F.
Gardner, R. T.
Geary, France
Geoghegan, Gordon
Gerig, Paul D.*
Gibson, T. B.*
Gill, John B.
Gillespie, Chester G.
Gilman, Richard H.*
Gladding, Charles
Glover, H. F.*
Gotaas, Harold B.
Graham, William
Graves, Walter C.*
Gray, Harold F.
Greenberg, Arnold E.
Gregory, John H.
Gregory, Theo. R.
Groves, James O.
Haagensen, Edward A.
Hager, Everett G.
Haines, Jesse E.
Hall, Mortimer L.
Hancock, Donald J.*
Hanna, W. J.
Haratani, Joseph
Harper, Travis C.
Harrison, Gordon L.
Harrison, John B.
Haseltine, T. R.
Haskell, B. P., Jr.
Hedge, W. Clifford *
Henderson, W. L.
Hennessy, Paul V.*
Hicks, H. S.
Hild, John F.
Hill, Clair A.
Hill, K. V.
Hodgkinson, Jack
Hogle, Robert, Jr.*
Holcomb, Scott
Holman, H. C.
Holmlund, A. E.
Holyoke, G. E.
Hopkins, O. C.
Horstkotte, G. A. Jr.*
Hoskinson, Carl M.
Howe, John B.
Howell, Eugene M.
Hubbard, William B.*
Huber, Samuel
Hubon, I. A.
Huebner, Ludwig
Huebscher, Raymond *
Huffman, Fred
Hume, Norman B.
Hutchinson, J. P.
Hyde, Charles Gilman
Hyde, Harlow, Jr.
Hyde, W. S.
Inerfield, Arthur J.
Ingram, William T.
Jacka, Sam C.
Jackson, Earl E.
Jeffrey, H. H.
Jenks, Harry N.
Jenks, John H.
Jennings, J. Carl
Jessup, A. H.
Johnson, Ivan L.*
Johnstone, D. T.*
Jones, F. Wayland
Jones, Phil R.
Jones, Ray W.
Jorgensen, Homer W.
Joseph, Earnest F.*
Junk, W. S.*
Kalichman, Samuel G.
Kaufman, Warren J.
Kaulbach, Howard S.
Keeler, Russell B.
Keirn, Kenneth A.
Kells, G. King
Kelly, Earl M.
Kennedy, F. K.
Kennedy, Richard R.
Kennedy, Robert M.
Kenyon, Gale O.
Kern Co. Dept. of Pub. Health
Kersnar, Frank J.*
Kimball, Jack H.
King, L. P.
Kivari, A. M.
Klein, Robert N.
Knapp, Hobart C.
Knapton, William
Knoedler, H. A.
Knudsen, H. A.
Koebig, Adolph H., Jr.
Kressly, Paul E.
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Lackner, J. E.
Lacy, Milo S.*
Langelier, W. F.
Larkin, Donald G.
Larsen, H. Peter *
Larson, John A.
Larson, Linnie C.
Lawrence, Edward M.*
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Lee, Charles H.
Leete, Gene V.
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Lonner, Harry W.
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Ludwig, Russell G.
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Lyons, Ivor A.
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MacPherson, William J.
Maga, John A.
Maldonado, Ardis
Mallery, J. C.
Manteca, City of
Manuell, William K.*
Marsh, Edward P.*
Martin, Arthur E.
Martin, Benn S.
Martin, H. E.*
May, Harold L.
Mays, T. J.
McCandless, Charles S.
McCarthy, R. E.
McCaslin, K. M.
McClain, Manford E.
McColl, Eli S.
McCormack, T. P.*
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McKee, Elwood B.*
McKee, Jack E.
McKinnie, M. B.
McLaren, Alfred M.
McLeod, William T.
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McMorrow, B. J.
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Milts, Harvey J.
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Moranda, Walter B.
Mott, Robert D.*
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O'Neill, Ralph W.
O'Hair, Charles H.*
Ongerth, Henry J.
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Owen, F. B.
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Parker, Vern A.
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Pearson, Erman A.
Peirson, Frank L.
Pelez, Harold *
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Pratt, Jack W.
Preen, Sydney
Prodanovich, Dahilo
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Quartly, Eric V.
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Reed, Frank R.
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Reinhardt, Arthur W.
Reinke, E. A.
Reinoehl, Don
Reynolds, Leon B.
Ribal, Raymond R.
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Richey, Curtis E.
Riegel, Harry I.*
Riffe, Norman T.
Rink, Henry
Roberts & Brune Co.
Roberts, W. C.
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Rogers, Raymond M.
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Ross, Elmer E.
Ross, J. A.
Ross, William A.
Ross, William A.
Russell, E. L.
Sanchis, Joseph M.
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Schneider, Ruben
Schneider, Warren A.
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Schultz, Irving
Schweining, Henry L.*
Senseman, William B.
Serpa, George R.*
Scholari, Emil
Segel, A.*
Seitel, G. C.
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Shearer, A. B.
Shilling, LaVern G.
Shook, H. E.
Short, Frank R.*
Silberbauer, W. R.
Siverts, Samuel A.
Smith, Chester A.
Smith, Guy R.*
Smith, J. F.
Smith, Sherwin T.*
Snider, H. I.
Snyder, John A., Jr.
Sotter, Ralph R.
Stanich, A. J.
Starns, R. M., Jr.
Stead, Frank M.
Stege Sanitary Dist.
Stewart, Morgan E.
Stone, Ralph
Stone, R. V., Jr.
Stowell, Edwin R.
Studley, Elbridge G.
Sukacz, Edward J.*
Summeril, F. J.*
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Sweet, Charles A.
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Thoits, E. D.
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Upson, Dick
Utah State Dept. of Health
Van Meter, Roy O.
Van Norman, J. H.*
Vieira, Arthur *
Visalia, City of
Wadsworth, Ralph G.
Walsh, Raymond *
Walters, Grover L.
Wanderer, W. C., Jr.*
Ward, Paul C.
Webster, Cedric
Weckel, W. O.
Weed, Sam A.
Weingarden, Elm *
Weir, Morley
Wells, Edwin A., Jr. *
Weltch, Paul D.
Werle, Armand E.
West, Alfred W.*
West, Ezra
Wheeler, William H.
White, George C.
White, Harry H.
White, R. E.
White, Wallace W.
Wicht, Edwin W.*
Wiggins, W. C.
Wilcox, Roger F.
Wilkinson, Ed A.
Williams, M. E.*
Williams, Roscoe W.
Winter, Alfred
Wintersgill, A. T.
Wise, Melvin J.*
Witz, Walter *
Wright, D. W.*
Wyatt, Bradley W.
Yantis, E. M.*
Yoder, M. Carleton
York, Charles E.
Young, John T.
Zoellner, Robert W.

CANADIAN INSTITUTE ON SEWAGE AND SANITATION

Allan, L. B.
Alport, Frederic *
Anderson, C. S.
Anderson, R. V.
Anderson, W. J.
Ansari, M. Y.*
Archibald, H. E.
Argo, John W.
Armstrong, C. G. R.
Ayers, Frank E.
Bailey, Harold M.
Bailey, Robert T.
Baird, E. M.
Baker, G. H.
Ball, Oliver V.
Ball, William F.
Barr, Melville
Battershill, J. W.
Bayard, G. A.
Beauchemin, J. A.*
Bell, Fred A.
Belleville, Laurier
Benoit, Jacques
Berkeley, Garnet L.
Bernhart, Alfred P.
Berry, A. E.
Beveridge, J. A.
Bibeau, J. A.
Bickell, A. H.
Borgford, T. B.
Bosworth, R. F. D.
Both, Jack
Bowering, R.
Bowser, Reginald
Bradley, Harold D.
Bradley, Whitney L.
Brakenridge, Charles
Brickenden, F. M.
Brisco, G. N.
Brown, Allan C.*
Brown, K. V.
Browne, F. G.
Brownridge, F. B.
Bubbis, N. S.
Buckley, E. J.
Burn, G. A. H.
Burnett, A. H.
Bye, Norval E.
Cabana, Les Paul
Cairns, K. C.*
Cameron, Alwyn J.
Campbell, R.
Carnwath, James
Carss, Harold W.
Case, C. William
Cassels, W. L.
Catto, R. W.
Caverly, David S.
Chaldecott, John J.
Chalmers, A. E.
Chenevert, J. G.
Chisholm, William O.
Clappison, J. H.
Claridge, R. E.
Clark, A. W. G.
Clarkson, G. H.
Clawson, W. K.*
Collier, J. D.
Collins, W. H.
Collison, Lloyd S.
Conant, F. M.
Copp, Stanley S.
Corcoran, J. D.
Corless, M. T.
Cosman, Ernest
Coulson, C. L.
Cousineau, A.
Cowan, D. C.
Craig, Hugo B. R.
Crase, George H.
Crawford, D. E.
Crawford, George B.
Crepeau, Louis
Currie, G. N. M.*
Currie, V. R.
Curtis, John K.
Cyr, Rene
Daly, James A.
Daly, Robert E.
Davey, Roland E.
DeLaporte, A. V.
Delisle, E. A.
Dempsey, W. T.
Deslauriers, A. J.
Desmarais, R. J.
Dexter, W. A.*
Dick, Charles
Dickey, H. R.
Dilworth, Harold M.
Disher, D. M.
Dobson, Gordon
Dufresne, Paul
Duncan, J. G.
Edmonds, W. R.
Edwards, Clement
Elley, John R.*
Elliott, Thomas E.
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Davenport, Max
Davis, Alan G.
Davis, Earl E.
Davis, Merle W.
DeGram, Arthur *
DeHooghe, Bernard A.
Delano, E. Huntley
Delano, Reuben G.*
Delos, John S.
Dempster, Andrew T.
Dennis, Carl E.
DePree, E. J.
Dewitt, C. C.
Dingler, E. L., Jr.
Dodge, Harland P.
Dornbush, Donald *
Downey, Royce L.
Doyle, Thomas J.
Drury, Walter R.
Du Bois, F. W.
Dye, Frank M.
Early, Frank E.
Eckelcamp, Joseph
Ellerbusch, R. P.
Ellis, N. T.*
Evans, J. B.
Fishbeck, Kenneth
Forton, R. Gerald
Fox, Leon D.
Francis, George W.
Frost, F. B.
Fuess, C. Edward
Gable, Tom S.*
Gannon, John J.
Garvelink, Frank
Gavan, William J.
Gehle, William A.
Gentsch, Edward
Georgeff, Steven
Gessner, Clayton
Gibson, William C.
Glysson, Eugene A.*
Goetz, Harvey J.
Gohlke, Howard R.
Graham, James E.
Granger, Dale W.
Gray, Richard
Greene, Howard W.*
Greene, R. A.
Grinnell, Russell
Groen, Michael A.
Gruner, C. T.*
Haberkorn, C. H., III
Habermehl, C. Austin *
Hamill, Harold F.*
Hansen, Alfred E.
Harju, John B.*
Harris, John H.
Harrison, C. F.*
Harrison, Louis B.*
Harvey, Chester
Hathaway, Clark W.
Hauer, Gerald E.
Hayward, Homer J.
Hazey, George
Hegle, Otto
Hebner, N. E.
Hennessey, John P.*
Heideman, H. W.*
Henry, T. B.
Hepler, John M.
Herring, C. M.*
Hicks, Cyril
Hikes, Burd
Hilbert, Morton S.
Hilgart, Arthur A.
Hillis, Leonard
Hordes, Herbert J.*
Howell, James L.
Hoxie, D. W.
Hubbell, George E.
Hunt, H. S.
Hurd, Frank D.*
Jackson, R. B.
Jennings, L. R.
Johnson, Clair L.
Johnson, George W.
Johnson, Russell L.
Jones, Frank E.
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Pessina, John *
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Pomeroy, Clarence
Porter, Howard P.
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Purdy, Ralph W.
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Ransom, Elmo B.
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Reedy, Timothy D.
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Sercu, Charles *
Shannon, R. C.
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Spicer, Clifford H.
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Ward, Carl W.
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Working, Lester
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Horner, W. W.
Kehr, William O.
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Kruegel, J. L.
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Lightfoot, Edward *
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Martin, Frank
McGrail, Paul J.
Mo. Div. of Health (L. E. Ordelheide)

Payton, Louis S.
Riddle, William G.
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Russell & Axon
Russell, George S.
St. Louis Public Lib.
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Chrysler, K. L.
Clarkson, Arthur W.
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Crabtree, Ernest *
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Dixon, M. F.
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Eggers, C. W.
Eyer, C. W.
Eyer, Chet
Foote, H. B.
Hall, John W.
Hamann, Oscar *
Hazen, John B.
Helena, City of (J. R. Kaiserman)
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Lefler, W. A.
Lovell Clay Prod. Co. (D. H. Denman)
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Owen, Harold
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Pepin, E. J.
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Staid, I. J.*
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Sullivan Valve & Engineering Company (T. J. Sullivan)
Swearingen, W. H.
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Brown, Edward S., Jr.
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Cahaly, Fozi M.
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Campanella, Joseph L.
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Delsanto, Thomas
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Dion, Clarence K.
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Doggett, William H.
Doman, Joseph
Donnini, Frank L.
Dopmeyer, Arthur L.
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DuPont, Anthony W.
Dutton, C. Sidney *
Easter, Leonard C.
Eddy, H. P., Jr.
Eliassen, Rolf
Faenza, E. Edward *
Fagan, L. A., Jr.*
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Faulkner, W. J.*
Fay, Roy M.
Fenn, Ernest G.
Ferris, James E.
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Flaherty, John F.
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Flood, Frank L.
Flood, Harold D.
Foote, Kenneth E.
Foster, Robert S.*
Frame, John D.
Fuller, Frederic D.
Fuller, James E.
Fynsk, Arthur W.
Garrett, Melrose T.
Gassett, Merton A.
Gaynor, Lester
Gehle, William A.
George, Herbert W.*
Gibbs, Frederick S.
Gilcreas, F. W.
Giles, J. Henry L.
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Goff, James S.
Goldman, Morton I.
Goossen, Henry
Granger, George M.
Grasso, S. P.*
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Greenstein, M. W.
Griffin, Guy E.
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Gurtlinger, John J.
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Hall, Herbert, Jr.
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Hanlon, Joseph B.
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Hartley, John R.
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Hoag, Arthur W.
Hogg, Dwight A.
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Howard, Earl R.
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Jenckes, J. F., Jr.
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Johnston, Charles T.
Jones, J. Ronald
Jones, Robert T.
Jordan, Edward C.
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Karalekas, Peter C.
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Kelley, Henry F.
Kenerson, Waldo I.
Kennison, Karl B.
Kent, Roscoe J.*
Keyes, Fenton G.
Kilgore, H. D., Jr.
Kincaid, James J.
Kinsel, Harry L.
Knapp, Charles A.
Knight, Charles E.*
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LaCava, Thomas A.*
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Lamothe, Wilfred
Langford, Leonard J.
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Lawrance, Walter A.
Lebetkin, George
Locke, Edwin A.
Lockwood, Bronson E.
Loftus, Harry P.
Logan, Thomas J.
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Lopez-Fuentes, Carlos
Lubker, Robert H.*
Lucas, Ernest H.
Lynch, William O.
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Mansfield, C. S.
Manter, P. R., Jr.*
Mariner, W. S.
Marston, Frank A.
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Masselli, Joseph W.
Masselli, Nicholas W.
Masterson, John R.
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McCarthy, Joseph A.
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McDonald, John D.
McDonald, M. C.
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McKinney, Ross E.
McMahon, Walter A.
Merrill, Walter E.
Merwin, Joseph K.

Miller, John D.
Mills, Benjamin, III
Misner, David M.
Mitchell, F. Burton
Moir, Robert W.
Moore, Edward W.
Moore, H. Carlton
Moran, John B.
Morgan, E. F., Jr.
Morgenroth, Frank
Morris, J. Carrell
Morse, William A.
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Munroe, Henry F.
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Oldaker, Warren H.*
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Palmer, Benjamin H.
Parker, L. K.
Pearson, C. Roger
Pederson, Haakon
Pedigree, Richard B.
Perkins, Charles A.*
Perry, Earl R.
Perry, Joseph A.
Peterson, Peter T.
Peterson, Stuart C.*
Petrie, William P.
Pfennig, Clair M.
Pillsbury, Harold W.*
Plainville Sew. Com.
Potter, Grant H.*
Puffer, Stephen P.
Ragaini, Frank
Raisch, William
Rankin, R. S.
Reed, Leon H.
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Rhodes, Robert W.*
Rice, Russell J.
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Riva, Charles W.
Roberts, John D.
Robinson, Thomas F.
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Rogers, John A.
Root, Darrell B.
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Sanderson, Wallace W.
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Sawyer, R. W., Jr.
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Shea, Walter J.
Shepperd, Frederick
Sherman, Leslie K.
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Sweeney, R. E.
Sweeton, A. W., III
Sylvia, Alexander D.
Szymanski, John R.
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Taylor, Worthen H.
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Vogel, Adalbert J. R.
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Wagner, Norman W.
Ward, James W.
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Weinberger, Leon W.
Wells, Alden
Wentworth, John P.
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Weymouth, Harold D.*
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Widmer, Wilbur J.
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Blattler, Paul
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Boyd, James J.
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Brown, William
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Gibbons, M. M.
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Goodfellow, J. W.
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Matthews, Frank
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Muss, Joshua
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Ocean City Sewer Service Company (E. S. Steelman)
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Valente, G. A.*
Van Der Vliet, Henry
Walker, James*
Weatherby, Thomas
Webster, Raymond A.
West, Leslie E.
Wharton, William L.
Wilbur, Karl
Williams, R. O.
Wilson, R. P.*
Wood, Robert R.
Woodstown Sew. Auth. (James M. Edwards)
Zablatzky, H. R.*
Zagar, Frank M.
Zeitler, Albert
Zydallas, Charles

NEW YORK SEWAGE AND INDUSTRIAL WASTES ASSOCIATION

Ace Pipe Cleaning Cont., Inc.*
(John H. Smith)
Adair, Duncan L.
Aeryns, Albert N.
Albertson, J. G.
Allen, George W.
Alloway, D. L.
Andersen, C. George
Anderson, Robert R.
Andreoli, Henry P.
Andrews, Joseph
Ango, Cona J.
Apostol, Louis T.
Arenander, Carl A.
Aries, Robert S.
Artale, John V.*
Artese, Philip
Associated Industries of New York State, Inc.
(Martin F. Hillinger)
Bafia, John J.
Bakenhus, Max
Ball, William J.
Bardet, Paul E.
Barker, Stanley T.
Barnum, William J.
Barrows, G. E.
Bates, R. D.
Becker, Hubert, Jr.*
Becker, John
Becker, Morris
Behrems, John W.*
Bennett, Christopher F.
Berk, M.*
Bernhardt, Carl J.
Berns, Milton H.
Besselievre, Edmund B.
Bessen, Seymour X.
Bethlehem Steel Co.
(P. F. Kinyoun)
Bhoota, Baboobhai V.
Bidwell, Milton H.
Biele, F. J.
Birch, John H.
Bird, G. C.
Bisset, Robert N.*
Blackett, S. W.*
Blaisdell, Edwin N.
Blanchard, Gerard E.*
Blood, Lloyd
Bogert, C. L.
Bogert, Ivan L.
Boggis, M. Carl
Borden Company
(Harry C. Ingerson)
Borden, Olney
Borncamp, W. E.
Bowe, Thomas F.
Boyce, Ralph E.
Boyles, William *
Bradlee, Warren R.
Bradner, Basil E.
Brallier, Paul S.
Brett, Sam *
Bretzer, Val
Brigham, John C.
Brigham, John C., Jr.
Bristol Laboratories, Inc.*
(J. D. McNitt)
Brower, J. Singleton
Brown, James M., Jr.
Brown, Kenneth R.*
Brown, Robert
Buck, George H.
Buono, Louis
Burdick, George E.
Burt, Otis M.
Bush, George H.
Byron, John C.
Caird, James M.
Carman, Simon P.
Carney, C. J.
Carpenter, Harry C.
Carpenter, Harry E.
Castell, Harold P.
Cerny, Paul J.
Chase, E. S.
Chasick, Abraham H.
Cherry, Alfred B.*
Chicago Bridge & Iron Co.*
(Paul R. Grossmann)
Christy, Robert Wesley
Chumard, Geary W.
Clark, Boyd H.
Clark, James W.*
Cocks, Martin J.*
Coffey, Michael J.
Cohn, Morris M.
Cole, E. Shaw
Conlon, Edward W.
Conniff, Thomas
Copeland, William R.
Costello, John J.
Cosulich, William F.
Cotton, Edwin R.
Coulter, Richard G.
Cowles, M. W.
Cox, C. R.
Coyne, James J.*
Cramer, Francis J.
Crane, Frederick W.
Crane, Harlan B.
Crippen, Huston D.
Critoph, Raymond
Culley, Walter M.
Cunetta, Joseph
Cuttica, Hector G.
D'Aleo, A. R.
Damron, Norman
Dancourt, C.
Dappert, Anselmo F.
Darby, W. A.
Davids, Herbert W.
Davidson, F. G.
Davidson, Maxwell D.
Davis, Clarence A.
Dawson, Arthur
Day, Robert V.
DeBrito, F. S., Jr.
De Falco, Paul, Jr.*
Deitch, Meyer
Dellasala, John J.
Dennelly, Philip G.
Devendorf, Earl
Dewart, Donald M.
Diachishin, A. N.
Dickey, George D.*
Dixon, G. Gale
Dobbins, William E.
Dobstaff, R. W., Sr.
Dobstaff, Robert, Jr.
Doman, Joseph
Donaldson, Wellington
Donohue, F. J.
Drautz, Kenneth E.*
Drexel, Frederick
Drummond, Robert M.
Dufficy, Frank J.
Dungan, E. Root
Dyckman, Warren W.
Eagleson, John W.
Eckstein, George J.
Edwards, Gail P.
Edwards, William L.
Eglof, Warren K.
Ehle, Virgil
Elder, Francis B.
Ellis, B. W.
Elmendorf, C. E.
Enslow, L. H.
Eustance, Arthur W.
Eustance, Harry W.
Everest, Howard
Faber, Harry A.
Fallon, Joseph A.
Farrell, William F.
Fay, Alan L.
Fawls, J. F.
Federick, Joseph C.
Feldman, M. M.
Fenger, J. W.
Fenton, John V.
Ferguson, Marshall E.
Ferris, James E.
Field, W. T.
Firth, William J.
Fischer, Anthony J.
Fitzgerald, J. A.
Fitz Gerald, Leo J.
Fitzsimons, Richard H.
Five, Helge
Flaherty, Hubert W.*
Fleet, Gerald A.
Forrest, Glen L.
Fortenbaugh, J. Warren
Foster, James R.
Fox, Arthur J., Jr.
Franks, Jerome
Frasher, Randall L.
Freuerick, R. H.
French, Richard C.
Friendly, Hugo H.
Fuller, N. M.
Fynn, George F.
Galizia, Frank J.*
Gates, Charles D.
Gavett, Weston
Gazley, S. Howard *
General Foods Corp.
(August W. Huge)
Gere, William S.
Germond, Earl
Gewecke, Gordon C.
Gifft, H. M.
Gilcreas, F. W.
Glace, Ivan M.
Goldman, Conrad *
Goodman, Alvin S.
Gorman, Richard C., Jr.
Gould, Richard H.
Gouveia, Wilbur R.*
Graham, William E.
Greiff, Victor C.
Grelick, David
Griffeth, F. B.
Griffin, Guy E.
Grippi, Vincent
Gross, Fred W., Jr.
Grossman, Irving
Grover, Robert H.
Grune, Werner N.
Guimaraes, Marcio D.
Gurtlinger, John J.
Gyatt, W. P.
Haberer, John C.
Hackett, Peter
Haley, Walter C.
Hall, Herbert, Jr.
Hallenbeck, Albert
Hamm, William C.
Hanna, George P., Jr.
Hanson, A. M.*
Hardenbergh, W. A.
Hardin, Eugene A.*
Harding, Harry G.
Harding, James C.
Hardy, C. Asa
Harriott, Lloyd G., Jr.
Harrison, H.
Hasl, Ludwig C.*
Haverlee, Arnold H.
Harvey, Carl
Hayward, Harold *
Hazen, Richard
Headden, E. Bartlett *
Hedgepeth, L. L.
Heidenburg, Howard
Heller, Austin N.
Hendon, H. H.
Hengerer, David W.
Hennigan, Robert D.
Herberger, Arthur H.
Herzog, Henry
Hess, Raymond W.
Hess, Seth G.
Higgins, Thomas E., Jr.
Hill, Milton T.
Hill, T. C.
Holcomb, Howard B.
Holroyd, Norman S.
Holt, Daniel J.*
Homack, Peter
Hooker Electrochemical Co.
(Robert F. Schultz)
Hopkins, L. S. R.
Hopper, Allen O.
Horgan, John J.
Horn, A. John
Horton, John P.
Howard, Edward
Howson, J. T.
Hroncich, Luke L.
Huber, Harold J.
Iadavais, Vincent A.*
Imbelli, C.
Ingram, William T.
Irish, J. Wilbur
Irving, Clifford E.
Jabon, Fred M.
Jahoda, Frank W.
Jamestown Electroplating Wks., Inc.*
(Lawrence A. Davis)
Jennings, James A.*
Jerge, Ray
Johnson, Herbert O.
Johnson, John W.
Johnstone, Alan
Jones, Daniel
Jordan, Harry E.
Kaiser, M. M.
Karlsteen, Gust. H.
Kass, Edwin A.
Kass, Nathan I.
Kassay, A. E.
Kaufman, Sumner
Keeler, J. Harold
Keis, F. J.
Kelleher, Joseph A.
Keller, L. M.
Kelsey, Walter
Kelz, L. B.
Kendrick, Edward J.
Kennedy, Robert C.
Kennedy, William
Kenny, Raymond P.
Kenny, Thomas V.*
Kieffer, Joseph D.
Kilcawley, Edward J.
Killeen, T. F.
Kilpert, Richard
Kirchgessner, N. H.
Kirsner, Charles
Kivell, Wayne A.
Kliegerman, M. H.
Klein, Arthur H.
Klinck, Frank
Knapp, Charles A.
Knowles, Coyle E.
Koch, Edward C.
Konwinski, S. Edward
Koplowitz, S.
Krehbiel, Theodore A.
Krieger, Herman L.
Krum, Harry J.
Krusen, George C., II *
Lacy, Ilbert O.
Lambert, Francis J.
Landesman, Herbert *
Lang, Martin *
Lang, Sheldon *
Lang, Theodore W.
Langford, Leonard L.
Langworthy, V. W.*
Lapham, Jerome F.
Larkin, W. H.
Leach, Walter L.
Leclercq, E. P.
Lee, W. R.
Leonard, Edmund A.
LeMieux, Bernard G.
LesVeaux, John F.
LeVine, Richard Y.
Lewis, John V.
Liguori, Frank R.
Lincoln, Robert A.
Linden, John A.*
Lino, F. H. A.
Lippelt, Hans B.
Lipschuetz, Morris
Logan, Robert P.
Long, Frank V.
Lorenz, K. P.
Lose, Charles, III
Losee, James R.
Lovatt, Ronald
Lynch, Daniel E., Jr.
Lynch, James T.
Lyng, Ralph
Macauley, J. W.
MacCallum, C.
MacCallum, Percy C.
MacCallum, Robert
MacCrea, J. M.
MacNaughton, D. T.
Mack, Frank
Mahler, Thomas J.

Maneri, Charles S.
Mann, Alfred H.
Mann, Karl M.
Mann, Uhl T.
Marks, Henry C.
Marra, Peter S.
Marshall, E. A.
Marshall, Leslie S.
Martin, A. E.
Martin, Alexander G.
Martin, Edward J., Jr.
Marx, Frank
Mathers, George
Mattison, Stanley A.
McCabe, Brother Joseph
McCormack, T. K.
McDonnell, George H.
McFarland, William H.
McInerney, Gerald J.
McKeeman, Edwin C.
McLaughlin, R. M.
McLean, George F.
McShea, James J.
Mechanik, Joseph
Meeker, Herbert J.
Michael, Fred C.
Middlebrook, Robert W.*
Miller, Nathan
Millerscheen, William F.
Mitchell, Robert D.
Mittelmark, Abraham *
Monks, Clair L.*
Monsell, Harry M.
Montgomery, William
Moore, George W.
Morehouse, Harry W.
Morse, William A.
Mowbray, George A.
Murphy, Jeremiah J.
Murphy, Reginald A.
Murray, Raymond H. N.
Murrell, Norman E.*
Myers, Charles C.
Nassau County Department of Public Works (Harold Sherman)
Nemecsek, Louis J.
Neubauer, Milton J.
Nichols, Arthur E.
Nicholson, C. P.
Nickerson, Robert D.
Niles, Charles A.
Nollett, Frank
Nussbaumer, Newell L.
Nussberger, Fred E.
Obergfell, Herman M.
O'Brien, Earl F.
Ockershausen, R. W.
O'Connor, Donald J.
O'Connor, William F., Jr.
O'Connor, William L.
O'Dell, W. H.
O'Donnell, Charles P.
Okun, Abraham H.
Okun, Daniel A.
O'Lear, Michael *
O'Leary, W. A.
O'Neill, O. M.
Orchard, W. J.
Ordway, E. S.
Ousterhout, Alfred
Palevsky, Gerald
Parsons, A. C.
Pascoe, Oliver K.*
Pawlak, John S.
Payn, Wallace M.
Peck, Lawrence J.
Perkins, C. K.
Phelps, Earle B.
Petrino, Sebastian A.
Phillips, H. N.
Pincus, Sol
Pinkney, Glenn E.
Pollock, John M.
Pope, Walter J.
Porter, William
Powell, A. R.
Pranich, Amnuay
Price, Richard B.
Probeck, Charles
Purdie, David J.
Raisch, William
Rankin, R. S.
Raymond, Allan E.*
Raymond, Walter A.
Rehler, J. E.
Remson, John K.
Republic Steel Corp. (J. D. Dickerson)
Requardt, G. J.
Reynaud, Joseph R.
Ribner, Morris
Rice, Lawrence G.
Rickard, Grover E.
Riddick, Thomas M.
Riedel, John C.
Rihm, Alexander, Jr.
Riis-Carstensen, Erik
Riley, Harley M.
Rivera-Bisbal, M. A.
Roberts, C. R.
Roberts, Hazel V.
Rocco, John
Rock, Harold F.
Roe, Frank C.
Roe, Joseph P.
Roesser, Robert
Romer, Harold
Rooney, John J.
Rushey, Donald D.
Rutkin, Nathan
Ryan, J. Samuel
Ryan, William A.
Saetre, Leif
Safford, M. A.
Sage, Howard D.
Saks, Irving J.
Salvato, J. A., Jr.
Samson, Channel
Sander, Irwin P.
Sanderson, W. W.
Santilli, Frank
Saville, Thorndike
Scanlon, Arthur J.
Schatz, Edwin C.
Schilling, H.
Schlickenrieder, W.
Schoen, Daniel I.
Schreiner, W. R.
Schrewe, Erwin W.
Schulhoff, Henry B.
Schuster, Arthur W.
Schwartz, Charles F.
Schwartz, Louis
Scoralick, Henry W.
Scott, Walter M.
Scovill, John R.
Scudder, A. P.
Searls, Glenn
Segel, Harvey L.
Seifert, William P.
Senior, Harold J.
Shapiro, Robert
Shepperd, Frederick
Sherman, Richard W.
Sherwood, Nial
Shie, Julius
Sigworth, E. A.
Simpson, Rolland W.
Sinclair Refining Co.* (C. L. Schmidt)
Slocum, Adelbert I.
Small, Harry
Smith, Benjamin L.
Smith, Edward J.
Smith, Ernest K.
Smith, Francis J.
Smith, Frank J.
Smith, Harold
Smith, Harry D.
Smith, Meloy
Smith, Morris B.
Smith, Willard R.
Snyder, H. Burt, Jr.
Snyder, N. S.
Solvay Sales Division, Allied Chem. & Dye Corp. (Norman C. Weil)
Soreff, J.
Southard, George E.
Sparks, William A.
Sparr, Anton E.
Spencer, Charles C.
Stach, Fred J.*
Stache, Paul
Stalbird, James A.
Stamm, D. E.
Stauffer Chemical Company (Thomas P. Turchan)
Staunton, Jack L.
Steffensen, S. W.
Stein, Fred C., Jr.
Steiner, S. K.
Steinfeldt, W. M.
Stepanek, C. H. B.
Stevens, Donald B.
Stevenson, Albert H.
Stewart, John G.
Stewart, W. H.
Stolley, George B.
Stolz, Stanley B.
Stratton, Charles H.
Straub, Conrad P.
Streander, Philip B.
Sumner, George H.
Sweeney, R. C.
Sweeney, Willard G.
Swenholt, John
Sylvester, William L.
Symons, George E.
Taggart, R. S.
Tamer, Paul
Taylor, Floyd B.
Taylor, Henry W.
Taylor, Warren G.
Terry, Frank
Tetzlaff, Frank
Thamasett, Otto E.
Thayer, Reginald H.
Thatcher, Fred A.
Thomas, R.*
Thomas, Samuel J.
Thompson, Thomas C.
Tiddy, William
Titterington, B. J.*
Torpey, Wilbur N.
Torrey, Bates, Jr.*
Toth, Albert S.
Townsend, Wisner R.
Tucci, Louis A.
Turner, Harry N.*
Van Denburg, J.
Van Deusen, E. J.
Velzy, Charles R.
VerDow, William H.
Verlinden, Albert
Vermont, Henry G.
Vernon, Fred A.
Voelker, Edward M.
Vredenburg, Edward L.
Vrooman, Morrell
Wagenhals, H. H.
Wagner, E. P.
Walker, Charles L.
Walker, James G.
Walsh, Charles T.
Walter, C. Richard *
Ward, Charles E.
Wardle, J. McClure
Warren, George D.
Watson, Clifford W., Jr.
Watson, Edmund J.
Watson, K. S.
Wechter, W. H.
Weil, Harold M.
Weisbeck, R. J.
Welker, Leland A.
Wendel, Leon H.
Werner, Gustave G., Jr.
Wescott, George A., Jr.
Westergaard, Viggo
Wetterholm, Harold L.
Wheeler, Robert C.
Whipple, Henry R.
Whitley, F. H.
Whitlock, Ernest W.
Wichmann, J. H.
Wilbur, Conrad C.
Wilcox, Arnold L.
Williams, John J.*
Williams, Walter E.
Wilson, C. R.
Winfield, Wilmer M.
Winget, Russell L.
Winick, David S.
Winne, George
Winthrop-Stearns, Inc. (Robert C. Annen)
Wolf, Robert B.*
Wolfson, David
Wolfteich, John
Wolin, Martin
Wood, Herbert M.
Wormuth, W. H.
Wright, Chilton A.
Wright, Paul J.*
Wyland, Gordon B.
Young, Alden W.
Zack, Samuel I.
Zoeller, August
Zollner, Frederick D.
Zubkoff, Seymour

NORTH CAROLINA SEWAGE AND INDUSTRIAL WASTE ASSOCIATION

Abernethy, J. F.
Adams, Robert R.
Adkins, W. W.
Ameen, J. S.*
Alexander, S. C.*
Andrea, John A.*
Andrews, John
Bailey, Hoyt G.
Baity, H. G.
Baynard, William G.*
Brown, John L., Jr.
Brown, W. G.
Bryant, Earl O.*
Caton, M. O.
Chanlett, Emil T.
Coburn, Darwin L.*
Colburn, Burnham S., Jr.
Crow, W. H.*
Culver, Robert H.
Dandridge, John W.
Davis, H. F.
Davis, P. D.
Dawson, Thomas T.
Dickson, W. K.
Duke, Lee S., Jr.
Dwiggins, Gordon L.
Ebert, R. E.
English, J. A.
Fesperman, H. Dewey *
Finck, Herbert F.
Fluharty, Joseph R.
Fowler, Arthur B., Jr.*
Franklin, W. M.
Fuller, V. E.
Gardner, Walter A.*
Granstrom, Marvin L.
Greenlee, J. L.
Grey, John C.*
Hall, W. H.
Hanks, W. W.
Harris, Stanford
Helms, W. R.
Henderlite, James H.
Heyward, T. C.
Heyward, T. C., Jr.
Hill, R. G.*
Hobson, Fred C.
Holder, D. O.
Houser, T.*
Howard, Paul N., Jr.
Howell, D. T.*
Hubbard, E. C.
Huffstetler, L., Jr.
Jacokes, J. W.
Jarrett, J. M.
Johnson, E. M.
Lassiter, L. I.
LeClerc, Arthur B.
Lloyd, M. P.
Long, Wilbur E., Jr.*
Long, William Noell
Luther, Robert W.
Malone, J. R.
Mannel, Charles
Mason, Carle W.
McKimmon, W. S.*
Mengel, Carl W.
Mills, Ralph *
Moore, George S.
Moses, James E.*
Mutzberg, F. A.
Nance, E. L.

Nemerow, Nelson L.
Olsen, W. C.
Peirson, Nat D.
Phillips, R. S.
Piatt, William M.
Priest, John J.
Purser, John R., Jr.
Rawlins, George S.
Redding, Harry P.
Riegel, H. J.
Rivers, Thomas W.
Roberts, C. A.
Rodgers, R. M.
Rose, Thomas D.
Safford, Truman H.
Setzer, J. Wilson
Sherrill T. R.,*
Skillman, Harold R.
Smallwood, Charles, Jr.
Snow, William B.
Solkoff, Ephraim
Stevenson, W. J.*
Stewart, Ronald G.
Swartz, Martin
Teeter, Henry R.
Tobin, David
Tull, E. R.
Tyler, Lloyd P.*
Umberger, C. Dwyer
Van Camp, Paul M.
Van Sleen, Robert
Williams, D. M.*
Whisenant, Dewey E.*
Whitman, J. A.*
Wilson, Robert A.
Witty, T. E.
Wooten, L. E.
Wooten, L. E., Sr.
Wright, K. W.

OHIO SEWAGE AND INDUSTRIAL WASTES TREATMENT CONFERENCE

Ake, Sam
Alspach, John R.*
Angst, C. L.
Armco Steel Corp.
(E. R. Mizer)
Aston, Royden N.
Backherms, A. B.
Backherms, Louis E.
Backlond, Maune
Backmeyer, David P.
Bailey, Burnett
Bailey, J. W.
Balharrie, Alex
Barker, John E.
Barkley, R. W.*
Barnes, George E.
Barnes, L. B.
Barrett, J. O.
Barstow, E. D.
Barton, Ben H.
Bass, J. H.
Bauer, Carl
Beck, Paul V.
Beckler, B. F., Jr.
Bell, Russell S.*
Berrey, Howard J.
Black, Hayse H.
Blank, Russel H.
Blodgett, James H.
Bloem, Herman
Blood, Frank A.
Bogardus, F. F.
Bogardus, Theodore S.
Bonham, H. E.
Borland, Sherwood
Bormuth, F. A.*
Boruh, Walter E.*
Bowers, H. R.
Bowers, Rolland G.*
Bowman, W. Robert
Braden, H. L.
Brandle, Donald A.*
Britt, C. E.
Brown, Aaron P.*
Browne, Floyd G.
Bryant, Charles T.
Buck, Arthur H.
Bull, C. C.
Bumstead, John C.
Burger, A. A.
Calihan, Resler H.
Camden, C. D.*
Cassidy, C. R.*
Caster, Arthur D.
Cate, Donald W.*
Cheston, Harold C.*
Cincinnati Chemical Works, Inc.
(James Crane)
Clay Sewer Pipe Assoc., Inc.
(Edward W. Hartman)
Cleary, Edward J.
Clift, M. A.
Clouse, John L.
Cochran, A. G.
Cochran, Omar Neil
Collier, James R.
Collins, J. L.*
Connors, F. H.
Conrad, Ward E.
Cook, Elmer E.*
Cooper, James
Cordray, R. A.
Cosens, Kenneth W.
Cowell, J. R., Jr.*
Craun, E. P.
Craun, J. M.
Crawford, Lawrence C.
Crohen, W. F.
Cunitz, George R.
Cupps, Clyde
Dannis, Michael
Danse, L. A.
Davidson, A. B.
Davis, William H., Jr.
Dixon, Frank N.
Dobb, Fenton H.
Ehrenfest, Paul *
Electric Auto-Lite Co.
(Allen M. Reed)
Ellis, Charles J.*
Emery Industries, Inc.*
(Erwin A. Emmer)
Eschliman, John *
Esterline, Harry
Ettinger, M. B.
Evans, Edmund B.
Fadgen, T. J.
Fee, H. J.*
Finkbeiner, Carleton S.
Finn, Richard H.
Fischer, F. P.
Fleming, George S.
Flickinger, L. C.
Flower, George E.
Frigidaire Division
(H. S. Kline)
Frook, James E.
Fuller, Raymond H.
Gard, Charles M.
Gehle, William A.
General Electric Co.*
(Larcern M. Corcoran)
General Motors Corp., Morain Products Corp.
(Frank J. Klein)
General Motors Corp., New Departure Division
(Marvin Pratt)
Gerdel, Walter E.
Gill, Frederick W.
Gingery, Roy D.
Goetz, H. J.
Goodrich, B. F., Co.
(H. C. Cook)
Graf, Walter W.
Graham, James D.*
Grant, Nye
Griffin, D. P.
Growden, H. C.
Gruber, Charles R.
Hagerty, L. T.
Hall, George A.
Hall, Raymond E.
Hamlin, W. G.
Hansen, Herbert W.
Hardesty, W. C., Co., Inc.*
(T. C. Alexander)
Harlamert, P. A.
Harris, W. R.
Harvey, Arthur R.
Hasenpflug, George
Hatch, B. F.
Hauck, Charles F.
Hauenstein, H. W.
Havens, William L. *
Hayes, Aubrey
Heffelfinger, Donald D.
Henn, R. B.
Henry, Thomas B.
Hedgepeth, L. L.
Hertenstein, Neil
Hess, John S.
Hibbs, Albert S.
Hill, Harold H.
Hilton-Davis Chem. Co.*
(Chester H. Allen)
Hoak, Richard D.
Hodge, W. W.
Hoffman, W. R.*
Holben, C. E.*
Holliger, R. L.*
Holzberger, Walter
Horlacher, George A.
Howard Paper Mills, Inc.
(Harold C. Koch)
Howell, G. A.*
Howell, Robert
Hoyt, Earle S.
Huffman, Lloyd C.
Hufford, L. E.
Hull, C. H.*
Hurst, George E.*
Inbody, Wayne
Ingram, William M.
Jacobs, W. H.
Johnson, Kiehner
Johnson, L. E.*
Jones, Frank W.
Kaercher, Wilbert T.*
Kayser, Charles
Keller, Earl D.
Kettering Laboratory
(Jules Cass)
Kinney, John E.
Knauer, Arthur T.
Kneale, James B.
Knox, W. Homer
Konrad, William N.
Koubak, J. V.
Kroone, T. H.
Kropp, E. P.
Krunich, M. D.
Kumnick, Lawrence R.
Langdon, L. E.
LaPlante, Ray *
LeRue, Luther
Lauber, R. M.
Lazaron, James S.
LeBosquet, M., Jr.
Lederer, Lewis M.
LeFeber, Alfred
Leist, Ervin F.
Lesher, C. E., Jr.
Lloyd, Kenneth M.
Long, George S.
Loveless, R. W.
Ludzack, F. J.
Lyman, C. S.
Mac Dowell, Rollin F.
Mace, H. Harlan
Mallette, Frederick S.
Mantor, Ray
Martin, Paul V.*
McBride, George A.
McCaughtry, William *
McCullough, Paul J.*
McCune, Franklin A.*
McCutcheon, James R., Jr.
McDill, Bruce M.
McGuire, C. D.
McIntyre, F. J.
McKeever, R. L.
McKenna, Walter T.
McManus, Hugh D.*
McQuattie, R. C.*
Mead Corporation
Meade, R. K.*
Meredith, G. B.
Meyer, Norcliffe
Miller, Paul C.
Mizer, Clifton *
Mock, Alvin M.*
Monroe, Stanley G.
Montgomery, J. A.
Moore, John R.*
Moore, Robert L.
Morehouse, W. W.
Morton Salt Company *
(T. S. Rader)
Mosely, Harry H.
Moyer, Jesse
National Cash Register Co.
(H. E. Austen)
National Refining Co.
(C. F. West)
National Supply Company, Engine Division *
(R. B. Harrison)
Newell, George W.*
Nielsen, Loren H.*
Niles, A. H.
Noll, Lawrence E.
Obarlin, Frank L.
O'Flaherty, F. O.
Ogden, Willis L.
Ohio Department of Natural Resources
(C. V. Youngquist)
Ohio Seamless Tube Co.
(H. R. Lewis)
Owen, Robert
Pacific Flush Tank Co.
Palmer, Howard M.
Palocsay, Frank S.
Parma, John W.
Parrish, Herman *
Patrick, K. M.*
Pattee, E. C.
Patterson, J. R.
Paul, Merl
Pease, Maxfield
Pettit, Charles G.
Pettit, Grant A.
Phillips, Max
Pollex, Elmer
Poole, R. W.
Powell, C. W.
Purk, Roy
Quinlan, R. T.*
Ranco, Incorporated
(D. J. Lemon)
Rarey, C. E.
Republic Steel Corp.
(Earle Smith)
Richards, John E.
Riehl, Merrill L.
Riestenberg, E. B.*
Roberts, Nelson
Robertson, John M.
Roman, J. B.
Ruck, Franklin
Rush, Karl K.
Sallisbury, F. D.
Sargent, Edward C.
Schade, W. F.
Schaetzle, T. C.
Schlechty, Eugene W.
Schmid, A. A.
Schoepfle, O. F.
Schoonmaker, George N.*
Schwemler, Frank L.
Schwieterman, E. T.*
Scott, Theodore
Seagrave, Alan V.*
Seferian, Samuel V.*
Seidel, R. David
Selby, N. G.*
Shaw, Walter F.
Sheets, W. D.
Singer, Oscar C.*
Singleton, Kelsie
Smith, A. O., Corp.*
(R. H. Myers)
Smith, E. E.
Smith, Guy F.*
Smith, Russell H.
Smith, Willard W.
Snavely, C. A.
Snyder, R. F.
Solms, E. D.
Specht, J. E.
Standard Oil Company
(Donald G. Stevens)
Stephen, P. C.
Stepleton, H. A.*

Stevens, Roger W.
Stilson, Alden
Straker, M. L.
Suhr, Arthur F.
Swab, Bernal H.
Swenson, J. R.*
Tatlock, M. W.
Teegarden, Hooper J.
Thayer, Paul M.
Thomas, Vernon B.
Thompson, George W.
Tolles, Frank C.
Tolman, S. L.
Towne, W. W.
Trautman, L. H.*
Trippel, Omer A.
Turner, J. R.
Uhlmann, Paul A.
Venrick, Robert *
Virginia-Carolina Chemical Corp.*
(C. S. Griffith)
Vogler, John F.
Waddell, M. C.
Walkenshaw, George B.
Walker, Carl C.
Walker, J. Donald
Walters, H. M.
Waring, F. H.
Warner, R. E.*
Warren, Edgar G.
Weaver, Titus
Weber, Robert R.*
Weinberger, Leon W.
Weise, William H.*
Wenger, J. H.
Weston Paper & Mfg. Co.*
(Harold C. Koch)
Wheeling Steel Corp.
(H. A. Stobbs)
Whitbeck, Raymond G.
Whitlock, J. B.
Wilcoxon, B. E.
Will, Edgar G.
Williams, L.*
Williams, Leon G.
Wirts, John J.
Wiseman, John W.
Wittenmyer, James D.
Wittmer, Earl F.
Wolfs, John R.
Woodruff, F. L.
Worthington Corp.
(Earle W. Vinnedge)
Wright, Carl D.
Young, F. D.
Zimmerman, Leslie L.

OKLAHOMA WATER, SEWAGE AND INDUSTRIAL WASTES CONFERENCE

Benham, Webster L.
Bennett, Leon
Brunton, J.*
Clark, C. D.
Clark, H. Homer *
Collins, Rex *
Cunningham, Morrison
Fellows, Fred G.
Graves, Quintin B.
Harrell, H. O.
Hoss, W. B.*
Hromada, Frank M.
Hume, J. S.
Hutton, M. L.
Klaffke, Kenneth
Lawrence, H. T.
Morris, Grover L.
Moutrey, C. E.
Mullins, John *
Schouten, Ernest W.
Settle, Lester L.
Shoebotham, T. B.
Smouse, John P.
Sprague, J. T.
Swab, Bernal H.
Taylor, Frank S.
Todd, Lee O.
Watt, Paul *
Williams, R. O.
Wingfield, F. E.*

PACIFIC NORTHWEST SEWAGE AND INDUSTRIAL WASTES ASSOCIATION

Alexander, Aleck
Alter, Amos J.
Armstrong, L. W.*
Barney, J. W.
Bartow, Leslie W.
Baun, James R.
Benjamin, C. E.
Bergerson, Wallace W.
Berkeley, Winston H.
Berntsen, Henry
Biladeau, Archie L.
Binford, Thomas A.
Blanchard, C. A.
Bless, O. A.*
Bollen, Walter B.
Bow, Wilson F.
Boydston, James R.
Brakenridge, Charles
Braun, Emmett H.
Briggs, Raymond J.
Brown, Clarence W.
Browne, Ben H.
Burgess, Frederick J.*
Burt, Gordon L.
Campbell, M. S.
Carey, James W.
Casad, C. C.
Chambers, Grover
Charlton, David B.
Clare, H. C.
Clark, A. W. G.
Clark, F. E.
Clark, Lloyd K.
Cornell, Holly A.
Cotta, Maurice L.
Crow, Harry B.
Cunningham, John W.
Cutting, Onie S.*
Cuyler, Clarence E.
Davis, Eugene F.*
Davis, Harold J.
Davis, J. Harold *
Donnelly, Henry J.
Early, M. W.
Edie, W. D.
Ekern, Andrew
Eldridge, E. F.
Emery, Forest M.
Everts, Curtis M., Jr.
Farrell, James K.*
Fitch, Henry M.
Flood, T. S.
Fowler, H. D.
Fox, Louis E.
Frick, A. L., Jr.
Gearhart, John B.
Gerow, Theodore M., Jr.
Gibbs, L. C.
Goode, N. J.
Goodnight, V. L.
Green, Carl E.
Green, Stewart G.
Groff, Gilbert
Haislip, Philip E.
Hallgren, Warren D.
Hamilton, R. F.
Hammond, George R.
Harris, Robert R.
Harris, Roy M.
Harstad, H. T.
Heath, J. Ray
Highton, James L.*
Hill, Allen E.
Hoey, James K.
Hoover, Gordon R.
Howard, C. M.
Howland, James C.
Hughes, William P.
Hyde, Obert R.
Ingman, Gordon G.
James, Roger
Jensen, Emil C.
Johnson, Lawrence *
Jones, Kenneth R.
Jones, P. E.
Jullum, Henry
Junk, Frank S.*
Kachelhoffer, Fred G.
Kalista, Godfrey
Kennedy, Richard R.
Ketchum, Lyman B.*
Ketteright, F. M.
Kipp, W. H.
Koch, Alwin G.
Koon, Ray E.
Kramer, Harrison W.
Kramer, Richard E.
Krause, Samuel *
Latimore, J. H.
Larson, Kenneth L.*
Leaver, Robert E.
Leete, Gene V.
LeMay, Andrew L.
Livesay, D. P.*
Livingstone, David
MacKenzie, Robert G.
Malony, W. L.
Mannes, Conrad O.
Maske, William *
Mathews, Kenneth E.*
Matthews, Willard
Maykoski, Robert T.*
Mayne, Arthur H.
McClain, E. C.
McCleary, E. L.
McCormick, J. L.
McGrath, Robert L.
McGuire, M. H.
McMains, Dale
McNamara, W. P.
Melton, James H., Jr.
Merryfield, Fred
Merryman, Harold W.
Meyer, Paul H.*
Moore, Emmett B.
Morris, David R.*
Morrow, Ben S.
Morton, William
Musgrave, A. S. G.
Nelson, Ben O.
Nelson, Fred G.
Nickel, Carl A.
Ofner, Frank R.*
Oliver, J. C.
Olsen, Carl S.
Olson, Kenneth F.*
Orlob, Gerald T.
Osborne, Francis T.
Parks, Clare A.
Patterson, Harold M.*
Perry, A. H.
Peterson, Roger B.*
Petty, Harold N.
Pratt, Jack W.
Reed, Clifford D.*
Quiner, John H.*
Rice, Archie H.
Roderick, Ralph E.
Ross, Donald L.*
Runyan, Marvin W.
Ruppert, E. L.
Sandel, Neil J.*
Saxton, Walter W.
Schroeder, Marvin H.
Seabloom, Robert W.*
Seabrook, C. S.*
Severence, Edwin S.
Sewell, H. A.
Shanahan, A. M.
Shera, Brian L.
Sisler, H. H.
Skooglund, Carl R.
Smith, C. Glen
Smith, Harvey J.
Smith, R. Trumbull
Smith, Wendell H.
Smithson, Thomas
Sneddon, Alexander W.
Snodie, Earl
Snyder, M. K.
Sparrow, Willis M.
Spaar, Leland L.
Spies, Kenneth H.
Stafford, Robert E.
Stillman, A. K.
Strate, Alfred R.*
Streeter, Ralph *
Stockman, R. L.
Sylvester, Robert O.
Strudgeon, George E.*
Templeton, W.
Thompson, H. Loren
Thompson, H. R.
Thompson, R. B.
Thorpe, Vernon
Trollier, Howard R.
Turner, Edmond S.
Tyler, R. G.
Visser, Harry A.*
Volpp, A. G.
Waggoner, Norman E.
Wagner, E. C.
Wahl, Andrew J.
Wallace, John R., Jr.*
Walton, Thomas *
Warburton, W. E.
Ward, Jonathan B.
Wark, James E.
Warner, E. L.
Warren, David *
Webber, H. A.
Weigand, Henry A.
Wellington, K. C.*
Westgarth, Warren C.
Westin, M. J.
White, L. R.*
Williams, Charles H.
Wolff, Richard E.

PENNSYLVANIA SEWAGE AND INDUSTRIAL WASTES ASSOCIATION

Abel, C. F.
Abington Township Public Works Department
(Oliver L. King)
Agulia, Frank P.*
Allegheny County Sanitary Authority
(J. F. Laboon)
Allen, James H.
American Home Foods, Inc., Chef Boy-Ar-Dee Division
(Andrew W. Machamer)
American Viscose Corp.
(R. M. Pfalzgraff)
Anderson, William M.
Appleton, Lester S.*
Armour Leather Company
(H. W. Rozenberg)
Art Metal Works, Inc. (Pa.)
(Howard A. Garaventi)
Attapulgus Clay Company
(Homer A. Smith)
Ayers, Lewis S.
Baffa, John J.
Bailey, S. C.
Bainbridge, David W.
Bale, Harvey E.*

Balmer, Robert R., Jr.
Bankson, Ellis E.
Barker, J. Conrad, Jr.
Barofsky, Max *
Barrett, Cecil H.
Barrick, M. J.
Baton, Warren U. C.
Baum, H. J.
Baxter, Samuel *
Beal, George D.
Beamesderfer, James A.
Beaumont, H. M.
Beechwood, C. T., III
Behn, Vaughn
Bennawit, William B.
Bentley, George T., Jr.*
Berry, Robert D.
Biddle, Charles C.
Bishop, C. A.*
Blizzard, Ernest
Boardman, John
Boardman, William H., Jr.
Bogardus, Theodore S.
Bole, Ralph D.
Bolenius, Robert M.
Boone, George H.
Bradac, Charles J.
Breter, William C.*
Brown, Glenn V.
Budd Company
Bush, Bernard S.
Cairns, Theodore *
Campbell, Floyd R.
Carter, N. C.
Cauffmann, L. E.
Caulwell, Wilson B.
Cerny, Paul J.
Chamberlin, Noel S.
Chase, E. Sherman
Cherry, James L.
Christy, Robert W.
Chubb, Robert S.
Clairton, City of
(John J. Mullen) *
Clark, Paul L.*
Clausen, William E., Jr.
Cleland, R. R.
Coburn, S. E.
Cochrane, J. C.
Codell, Winfield S.
Cohn, Herbert A.*
Coltart, Rodney F.
Cooley, H. W.*
Corddry, W. H.
Cornelius, F. V.*
Corning Glass Works
(Peter Grego)
Corson, G. & W. H., Inc.
(L. John Minnick)
Corson, Oscar
Corson, Simon C.
Cosner, Lafayette
Crawford, Samuel
Crawley, George M.
Cree, J. Gordon
Cushman, J. A.
Cusick, Arthur C.
Dailey, Jack *
Daly, Walter J.
Damon, H. Gilroy
Daniels, F. E.
Darby, W. A.
Davenport, H. S.
Davis, Edward T.
Day, Dewayne D.*
DeBourke, Robert P.*
Degnan, James M.*
DeMann, Joseph G.
DeWire, Harry A.
Dickerson, Bruce W.
Disston, Henry & Sons, Inc.
Divell, Arthur K.
Dore, Stanley M.
Dorworth, C. D.
Dravo Corporation,
Machinery Division
(William A. Walton)
Durr, John P.
Eberle, J. F., Jr.
Eddystone Mfg. Company
(Paul B. Wendler)
Edgerley, Edward
Edwards, Myles W.
Elkin, Harold F.
Elkland Leather Co., Inc.
Elliott, Edward H.
Emerson, C. A.
Embreeville State Hosp.
Empire Box Corporation
(H. L. Joachim)
Eppley, Robert G.*
Estrada, Alfred A.
Evans, David A.
Falciani, R. A.
Farrell, J. R.
Fawls, James F.
Fehr, C. M.*
Ferguson, John A.*
Ferris, Frederick
Fetch, John J., Jr.
Fieldhouse, George E.
Finley, J. J., Jr.*
Flavell, George J.
Fleming, M. C.
Foth, Harry C.
Fox, Joseph M.
Fox, M. L.
Freeburn, H. M.
Friel, F. S.
Frymoyer, George, Jr.*
Fuehrer, Carl W.
Fulmer, John O., Jr.
Gallmeyer, David M.
Garlow, William A.*
Garrity, Russell
Gavett, Weston
Gehle, William A.
Gehman, Harry W.
General American Transportation Corp.
(H. W. Pearson)
Gentleman, Lawrence M.
Gies, Russell W.
Gilbert, J. J.
Gill, Paul
Gillard, George T.
Gittins, John W.
Glace, I. M., Jr.
Glace, Ivan M.
Glueck, Frank J.
Gorman, William A.
Graham, A. Kenneth
Grandinetti, John R.*
Gray, J. P.
Greenawald, Paul B.
Grossart, L. Phaon
Grube, Karl W.
Gruss, John G.
Gushard, Robert R.
Gutterman, Bernard *
Gwin, Lewis L.*
Haddock, Fred R.
Hagerich, J. N.
Hager, Walter R.
Hall, George A.
Hamilton, John J.
Hamme, Donald G.
Hammond, Harry P.
Hampton, Quentin L.
Harris, Robert G.*
Hart, W. B.*
Harvey, J. R.
Haseltine, T. R.
Hauck, Charles F.
Hawes, Milton B.
Haworth, J. V.
Haywood, R. W., Jr.
Hearsmann, W. P., III
Heller, C. F.
Hendrickson, King H.
Hess, Daniel J., Jr.
Hess, Edward C.
Hewish, Edgar
Hibschman, Charles A.
Hicks, Arthur S.
Hill, T. C.
Hill, Edward S.
Hoak, Richard D.
Hobenzack, Frank C.
Hodge, W. W., Sr.
Hoeflich, G. C.
Hoffert, J. R.
Hoge, Charles C., II
Hood, John W.
Hoot, Ralph A.
Howard, Walter S.
Howell, G. A.
Huffman, Byron H.
Hunt, K. H.
Hutton, H. S.
Iezzi, Thomas
Imbt, M. Russell
James, Thomas E., Jr.
Johns, Alex W.
Johnson, Earle P.
Johnston, Charles T.
Johnston, Robert M.
Johnston, W. D., Jr.
Jones, Frank W.
Jordan, Claude W.
Kaiser Metal Prod., Inc.
(T. M. Robbins, Jr.)
Kappe, S. E.
Kase, C. DeWitt
Kelly, Walter J.*
Kielkopf, Frederick J.
Kimball, L. R.*
Kinderman, William
Kisiel, Chester C.
Kivell, Wayne A.
Klein, Lewis
Kline, Robert S.
Kluck, Charles R.
Knapp, O. H.
Kountz, R. Rupert
Krause, Mark C.
Kreidler, Carl *
Kremer, Robert W.
Krum, Harry J.
Lamplugh, Jesse R.
Lancy, Leslie E.
Langford, Leonard L.
Lawson, E. F.*
LeGrys, H. J.
Leh, Willard
Lehmann, Arthur F.
LeVan, Howard A., Jr.
Lewis, C. J.
Link, William E.
Long, Frank V.
Longley, Paul N.
Lubrecht, Frank
Luff, R. M.*
Lynott, William J., Jr.*
Mallory, Edward B.
Mansfield, M. G.
Marshall, William D.*
Matter, L. D.
McDonald, Joseph P.
McElhaney, Harry W.
McIntyre, Alex A.
McMillen, C. L.
Mebus, Chester W.
Mebus, George B.
Meeser, George C.*
Merkel, Paul P.
Merman, Robert G.
Meyers, Fredric R.*
Miller, J. John
Miller, Robert F.
Milligan, Francis B.
Moncrieff, James I.
Moore, Charles A.
Moore, J. Newlin
Morris, Edward P.
Morris, T.
Morse, William A.
Moses, H. E.
Mowry, R. B.
Moya, Victor Jose *
Muckinipates Authority *
(Harry L. Simon)
Mulvihill, Francis J.
Murdoch, William J.
National Distillers Prod. Corp.
(Thomas F. Brown)
National Tube Company
(I. V. Johnson)
Nelson, H. Lloyd
Nickerson, Robert D.
Nicholes, Curtis
Ohl, Warren H.
Olewiler, Grant M.
Ott, Anthony
Owen, Mark B.
Pahel, Charles
Pardew, W. Holmes
Paulette, Robert G.
Penn. Salt Mfg. Co.
Pepperman, Cecil M.
Perry, Robert R.*
Pettit, Grant A.
Pfannmuller, H. C.
Phelps, Wylie P.
Philadelphia Gas Works Co.
(Thomas B. Tinney)
Phillips, Roy L.
Pittsburgh Coke & Chem. Co.
(John E. Sigler)
Pollock, G. E.
Price, J. P.
Priester, Max U.
Protzeller, Raymond J.
Quaker Chemical Prod. Corp.
(Elwood Derr)
Reed, Thomas F.
Reese, Marshall
Regnier, R. C., Jr.
Reilly, John J.
Remig, Russell L.*
Remsen, Irving B., Jr.*
Reuning, Howard T.
Rice, C. K.*
Rice, Lawrence G.
Rickenbach, Howard F.
Roberts, John D.
Rogers, D. Paul
Rogers, Harold L.
Rohm & Haas Co.
(Benjamin F. Bolton)
Rosengarten, W. E.
Rudolph, Eldras B.*
Rutherford, Norman P.
Samsel, John J.
Schad, Fred
Schatz, Robert J.
Schaut, George G.
Scheffer, Louis K.
Schindler, H.
Schwartz, H. L.
Searight, George P.
Sears, Dow I.
Seewald, Seth E.*
Segraves, John W.
Seymour, Raymond B.
Sheaffer, G. Edgar
Shealer, Robert T.*
Sheen, Robert T.
Sherratt, Gayle F.
Shertzer, J. H.
Shields, James L.
Shiffer, Russell R.
Shinton, R. H.
Showalter, Charles M.
Sieber, John D.
Siebert, Christian L.
Siebert, C. L., Jr.
Simpson, Rolland W.
Sivyer, William
Slaby, Francis J.
Smith, Bernard F.
Smith, Harry J.
Snyder, Raymond H.
Soden, William W.
Somner, Franklin L.*
Spotts, Walter E.
Stewart, William E.
Stiemke, Robert E.
Stouck, V. M.
Stout, R. P.
Stroh, Charles K.
Stutzman, Robert F.*
Susa, Stephen A.
Swartz, Carl J.
Swinehart, Eugene B.
Taber, Douglass *
Tark, M. B.
Tarman, John E.
Tatlock, M. W.
Taylor, Henry W.
TenBroeck, E. H.
Thomas, Robert K.*
Thompson, Howard F.
Tomlinson, Daniel W.
Trebler, H. A.
Triggs, J. Fred
Turnbull, Harry
Union Switch & Signal Co.
(F. J. France)
Varner, Frank S.
Volk, James V.
Wagner, Edwin B.
Wagoner, John F.
Waligora, John M.
Walker, Donald T.*
Walker, Emerson *
Wanich, Glenn C.

Warner, Edward J.
Weachter, Horace *
Weber, Adolph
Weidner, Lawrence
Weiland, Luther
Wertz, C. F.
Westinghouse Air Brake Co. (DeWitt L. Shelly)
Weston, Roy F.
Whisler, B. A.
Whiteman, Daniel S.
Wiest, Gordon J.
Wilbur, Conrad C.
Williams, Henry C.
Williamson, Frank M.
Wilson, L. A.
Wilson, Walter A.*
Wilt, Marlin E.*
Wingert, C. E.
Woodward, John D.
Worrest, Howard A.
Wright, John, Jr.
Yenchko, John
Yenser, Robert *
Yeoman, Raymond E.
Yerkes, John B.
Young, C. H.
Zack, Samuel I.
Zellers, R. E.*
Ziegler, Alvin

PUERTO RICO WATER AND SEWAGE WORKS ASSOCIATION

Acevedo-Quintana, F.*
Auld, Robert
Bosch, Felipe
Bras, Rafael *
Robles, Luis R.
Sasvedra, Emilio F.*

ROCKY MOUNTAIN SEWAGE WORKS ASSOCIATION

Adams, Thomas C.
Baldwin, T. H.
Bassett, Robert J.
Bennett, Carl M.
Blunt, D. E.*
Caldwell, Charles G.*
Candell, E. J.
Cederberg, C. R.
Christenson, C. W.
Coberly, Carroll H.
Connolly, James J.
Coors, Adolph, Company * (Howard V. Lewis)
Couper, John *
Cox, Buford B.
Dallemand, G. E.*
Finney, John H., Jr.*
Foster, Robert F.
Franks, John T.
Gahr, William N.
Glass, Harry J.
Graham, Maynard
Grand Junction, City of *
Harness, C. E.
Hermann, Edward R.
Howe, Ben V.
Hunter, John M., Jr.
Jenks, Glen
Johnson, C. Robert
Kepner, Dana E.
Lambert, George
Lancaster, Frank H.
Leffel, Ernest R.*
Logsdon, Ora
Lowe, Robert P.
Martinez, J. E.
Moeller, Dade W.
Moore, Theodore L.
Morgan, Clifford L.
Neilson, N. P.
Osborn, L. C.
Osenbaugh, R. J.
Palmes, G. H.
Pyle, R. H.
Runyan, Damon
Ryan, Alfred J.
Rymer, Mary E.
Sanchez, Herman
Sherard, Ray L.
Spencer, Jay W., Jr.
Smith, R. A.
Streeter, Robert L.
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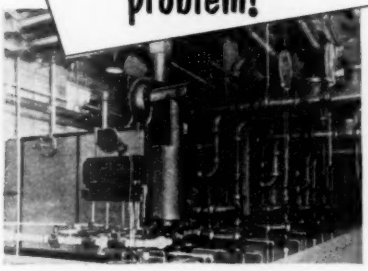
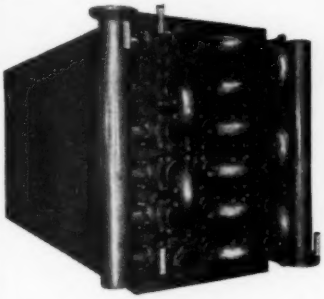


Akron, Ohio, Sewage Treatment Plant–Eight P.F.T. No. 1000 Digester Heaters and Heat Exchangers serving six digesters. 8,000,000 B.t.u./hr. combined output. Four are sludge gas fired – four gas and oil fired. Havens & Emerson, Consulting Engineers.



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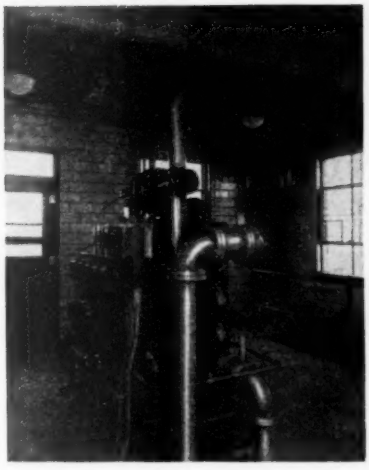
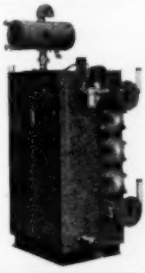


Northern Indiana State Hospital, Westville, Indiana–One P.F.T. No. 100 Heater and Heat Exchanger for sewage gas and oil firing. Boyd & Phelps, Consulting Engineers.

Norwich, Connecticut (Veterans Hospital) –One P.F.T. No. 100 Digester Heater utilizing steam from hospital power plant and arranged for future conversion to gas and oil firing. Argraves & Mort, Consulting Engineers.



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Proceedings of Member Associations

MISSOURI WATER AND SEWERAGE CONFERENCE

The 1952 Annual Meeting of the Missouri Water and Sewerage Conference was held jointly with the Missouri Section, AWWA, on September 21–23 at the Hotel Governor, Jefferson City, Mo. A total of 225 persons registered for the meeting.

At the Annual Banquet, the Federation's Bedell Award was presented to N. T. Veatch, Consulting Engineer, Kansas City, Mo.

Officers elected for 1952–53 were:

Chairman: W. B. Schworm, Chesterfield.
Vice-Chairman: J. Ramsey, Kansas City.
Secretary-Treasurer: W. A. Kramer, Jefferson City.

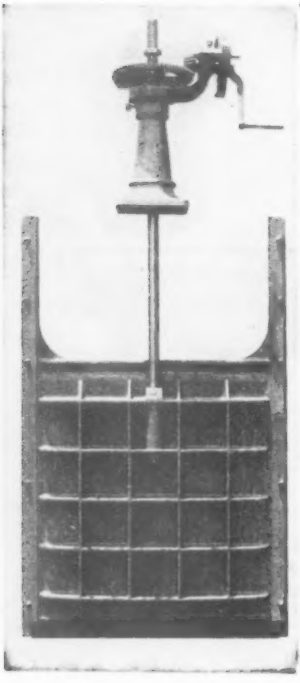
SOUTH CAROLINA WATER AND SEWAGE WORKS ASSOCIATION

The Sewage and Industrial Wastes Section of the South Carolina Water and Sewage Works Association met in the offices of the Secretary-Treasurer on Aug. 29, 1952.

Officers elected to serve during 1952–53 were as follows:

Chairman: M. Bright, Lyman.
Vice-Chairman: F. Gibson, Greenville.
FSIWA Director: T. E. Robertson, Jr., Spartanburg.
Secretary-Treasurer: W. T. Linton, Columbia.

George A. Rhame was nominated to receive the Federation's Arthur S. Bedell Award.



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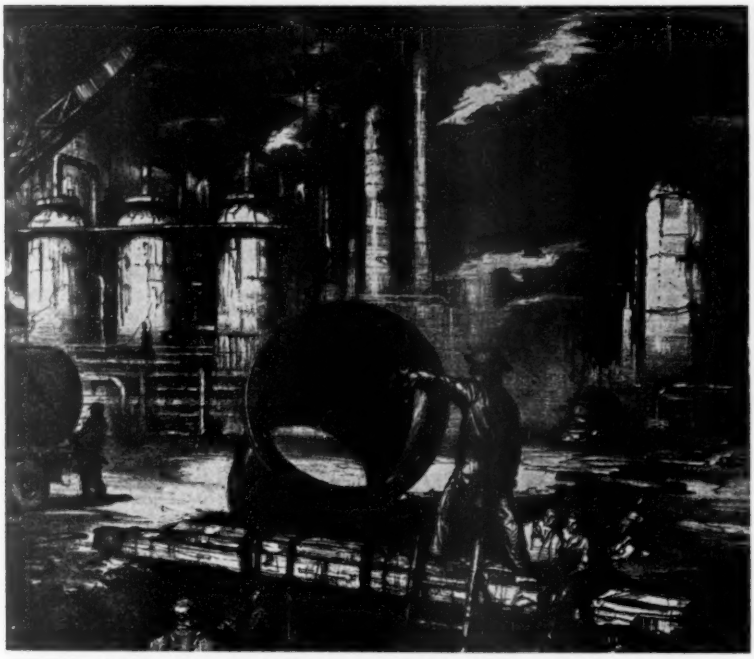

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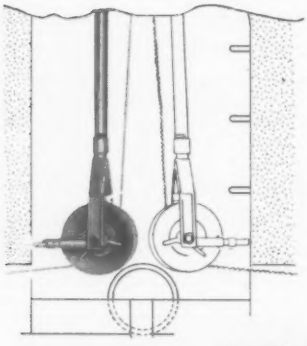

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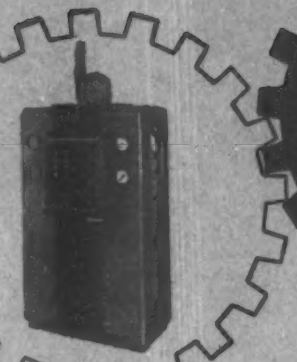

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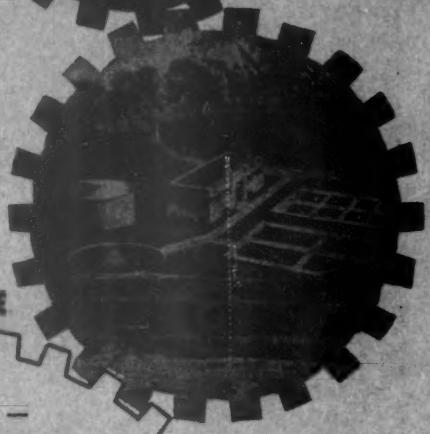

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